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ROYAL AND DISTRICT AGRICULTURAL SOCIETIES' 50-ACRE CROP COMPETITIONS, 1938.

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During the past eighteen years, the Royal Agricultural Society has promoted crop competitions amongst district Agricultural Societies in the wheat belt. On account of the great variation in soil and climatic conditions the wheat belt has been divided into eight zones in such a manner that districts having similar interests and climatic conditions are grouped together. In this way farmers compete with each other more equitably. The zones referred to are shown in the accompanying map.

Entry for these competitions is made through the affiliated district Agricultural Societies. The first and second prize-winners of these district competitions, provided these are conducted under the conditions laid down by the Royal Agricultural Society, automatically become eligible to compete for the prizes offered by the Royal Agricultural Society. Some Societies, however, make no provision for crop competitions, and in order that farmers in these districts may not be debarred from participating, the Royal Agricultural Society permits them to enter for the competition direct with them.

In each zone a championship prize of £10 and a second prize of £2 10s. are awarded. In addition to these prizes, the Royal Agricultural Society offers a special prize of £5 5s. to the competitor, in any zone, who obtains the highest calculated bushel yield per acre.

The conditions of the competitions require that the crop shall be grown on fallowed land; shall be not less than 50 acres in a compact and unbroken plot of one variety; and shall be judged under the following scale of points:—

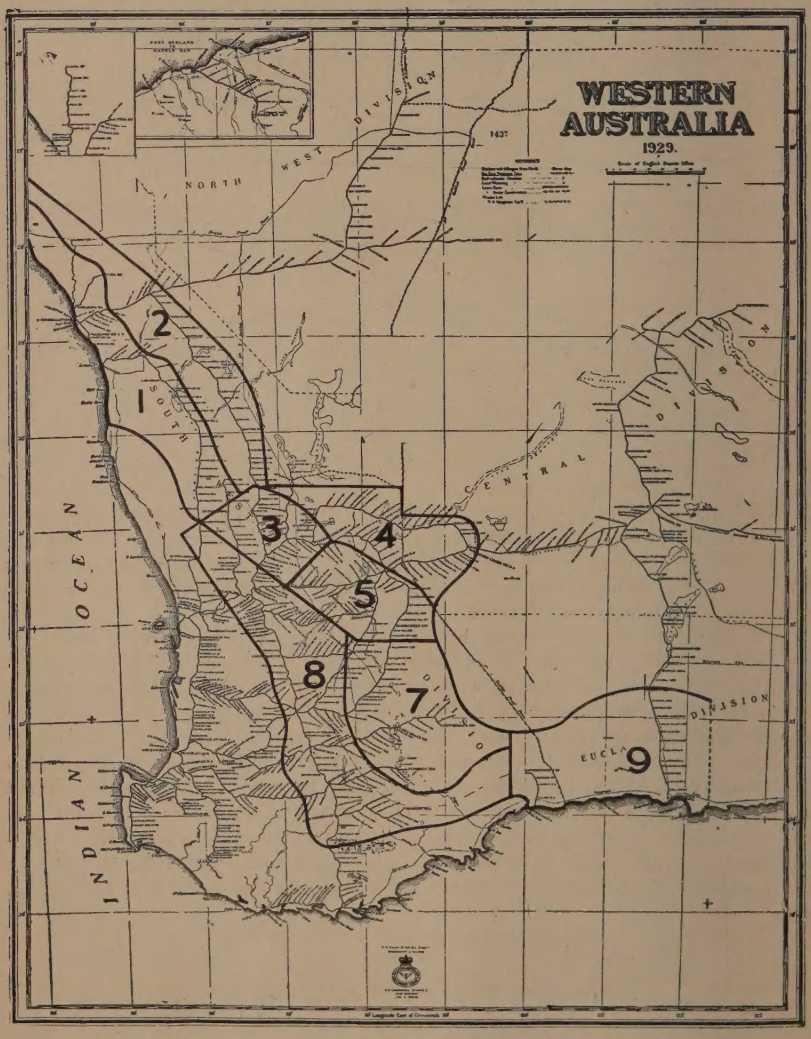
Yield	50 points
Freedom from Weeds	10 „
Freedom from Disease	10 „
Freedom from Admixture	15 „
Evenness of Growth	15 „
Total	100 points

The practice is to allot one point for each bushel of calculated yield per acre, which is determined by taking quadrat samples systematically throughout the crop, and then threshing and weighing the grain.

Since the inception of these competitions, the Judges have been Departmental Officers attached to the Wheat Branch. All the competition crops in each zone are inspected and the awards for the championship prizes made by the same Judge.

The Season.

Following a dry summer the season commenced well with above average falls during the early part of March, but unfortunately these early rains were



not followed up by satisfactory timely falls, April, May and June being months of abnormally low average rainfall. The lower rainfall areas suffered most severely through the whole of this period and in the latter part, the adverse conditions were very severely felt in the Northern and North Eastern areas.

Widespread rains mainly in the latter part of July altered the whole seasonal outlook and the crops made a remarkable recovery. The August rains, although disappointing, were well spread over the month and enabled the crops to make good growth. The rainfall in September and October was, however, well below normal, and the cumulative effect of the rain shortage through the whole of the season, especially from August onwards, has been reflected in the yields.

ZONE 1.

Judge—J. H. Langfield, Manager Merredin Research Station.

Competitors—Moora, 4; Three Springs, 6; Royal, 1; Total, 11.

The rainfall recorded at the centres concerned was as follows:—

	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total for Year.
Moora		5	174	184	151	276	436	169	115	51	1,198	104	1	1,666
Coorow		7	169	175	52	100	357	107	76	32	724	75	49	1,199
Three Springs	17	20	75	172	60	80	312	162	66	17	697	41	....	1,022
Bindi Bindi		....	33	146	263	304	59	288	89	12	1,015	96	....	1,290

Tables showing the Judge's awards and details of the treatment received by the leading competing areas are set out hereunder:—

MOORA AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Tonkin, J. A., & Sons	Coomberdale	Bencubbin	38	9	9	14	14	84
Adams, R. H.	Bindi Bindi	Ranee	37	9	9	13	14	82
Isbister, J.	Moora	Dundee	37	9	8	13	13	80
Hockridge, W. J.	do.	Merredin	33	9	9	13	13	77

Mr. J. A. Tonkin & Son's winning crop of "Bencubbin" was grown on salmon gum country which had not been cropped for two years before being ploughed in June 1937, with a mouldboard plough. This land was not touched again until early April when it was springtyne cultivated and then seeded during the last week of April with a combined cultivator-drill, seed and superphosphate being applied at the rate of 60 lb. and 112 lb. per acre respectively. Owing to rank early growth this crop was lightly fed off twice.

The crop of "Ranee" entered by Mr. R. M. Adams was grown on York gum and jam country which had been fallowed in early August, 1937, with a disc plough. No further cultivations were given to the land prior to seeding when it was sown with a combined cultivator-drill during the first week in May; seed and superphosphate being applied at the rates of 50 lb. and 90 lb. per acre respectively.

Mr. J. Isbister's crop of "Dundee" was grown on York and salmon gum country which had been under cultivation for the past 25 years. The land was ploughed in August, 1937, with a disc plough to a depth of approximately 3 inches and cultivated prior to seeding, which was done during the first week of May with a combined cultivator-drill. Seed and superphosphate were applied at the rates of 60 lb. and 105 lb. per acre respectively. This crop had also been fed off in its early stages.

THREE SPRINGS AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Franklin, E. W.	Three Springs....	Bencubbin	33	8	9	14	14	78
Olden, S. R.	do.	do.	32	9	9	11	13	74
Davey, E.	Arrino	Gluclub	32	7	9	12	12	72
Hebiton, J. K.	Three Springs....	Merredin	29	8	9	13	13	72
Williamson, A. M.	do.	Nabawa	30	7	8	14	12	71
Bertiotti, J.	Arrino	Merredin	21	9	9	13	14	66

The winning crop, "Bencubbin," entered by Mr. E. W. Franklin was grown on York and salmon gum country which had been cleared for approximately 30 years. It was ploughed in July, 1937, with a disc plough to a depth of 4 inches and cultivated during the spring with a springtyne implement. Seeding was carried out during the first week in June; seed and superphosphate being applied at the rates of 50 lb. and 90 lb. per acre respectively.

Mr. S. R. Olden's crop of "Bencubbin" was also grown on York and salmon gum country which had been cleared for 20 years. This land was cultivated twice during July, 1937, with a rigid tyne cultivator. It was again cultivated with the same implement before seeding, when 53 lb. seed and 103 lb. superphosphate per acre were applied by means of a combined cultivator-drill.

The crop of "Gluclub" entered by Mr. E. Davey was grown on jam country which had been ploughed in July, 1937, with a disc plough and ploughed back in April, 1938, just prior to seeding. Seed and superphosphate at the rates of 49 lb. and 90 lb. per acre, respectively, were sown with a combined cultivator-drill during early May.

ROYAL AGRICULTURAL SOCIETY.

Competitor.	Address.	Society.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Tonkin, J. A., & Sons	Coomberdale	Moora	Bencubbin	38	9	9	14	14	84
Adams, R. M.	Bindi Bindi	do.	Ranee	37	9	9	13	14	82
Bothe, B. D.	Coorow	Royal	Bencubbin	36	9	9	14	14	82
Franklin, J. W.	Three Springs	Three Springs	do.	33	8	9	14	14	78
Olden, S. R.	do.	do.	do.	32	9	9	11	13	74

Mr. B. D. Bothe's crop of "Bencubbin," which shared second place with Mr. R. M. Adams' crop of "Ranee," was grown on salmon gum country which had been under cultivation since 1914 and was fallowed in July, 1937, with a disc plough to a depth of 3½ inches. It was rigid-tyne cultivated in August and September, 1937, and again in April, 1938. Seeding was carried out during the middle of May; seed and superphosphate were applied at the rates of 60 lb. and 180 lb. per acre respectively.

ZONE 2.

Judge: F. V. Knapp, M.D.A. (Hons.), B.Sc. (Agric.) Agricultural Adviser.

Competitors: Perenjori, 2; Royal, 6. Total, 8.

The rainfall recorded during the year at the centres concerned in this Zone was as follows:—

	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total for year.
Damboring	65	8	178	117	29	98	269	99	86	15	596	53	17	1,034
Perenjori	2	5	141	149	43	62	349	108	51	16	629	48	....	974
Bowgada	33	15	40	102	48	45	251	60	28	15	447	63	2	702
Indarra	26	15	143	96	55	40	327	115	31	8	576	30	1	887

Tables showing the Judge's awards and details of the treatment received by the leading crops are set out below.

PERENJORI AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Davis, S. T.	Bowgada	Merredin	23	8	7	14	13	65
Helwig Bros.	Perenjori	Dundee	21	8	9	12	12	62

The winning crop of "Merredin" entered by Mr. S. T. Davis was grown on York gum, jam and mallee country which had been cleared eleven years. This

land, which is worked on the 3-year rotation (fallow, crop, pasture) was ploughed with a disc cultivating plough in June and August to a depth of 3½ inches. It was then springtyne cultivated during the summer months and again after the heavy rains in March, 1938. Seeding was carried out during the middle of May, the rates of seed and superphosphate being 38 lb. and 112 lb. per acre, respectively.

Messrs. Helwig Bros.' crop of "Dundee" which was awarded second place was planted on country that had previously carried York gum and ti-tree. It was ploughed in July, 1937, to a depth of 3 inches with a disc implement and reploughed in August. It was seeded during the middle of May with a combined cultivator-drill. Seed was sown at the rate of 48 lb. per acre and superphosphate at 90 lbs. per acre.

ROYAL AGRICULTURAL SOCIETY.

Competitor.	Address.	Society.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts.	10 pts.	10 pts.	15 pts	15 pts.	100 pts.
Moore, Hon. T.	Indarra	Royal	Dundee	31	7	9	13	13	73
Butcher, O. J.	Pithara	do.	Gluclub	26	8	9	12	14	69
Bradford, R.	Damboring....	do.	Bencubbin	26	8	8	12	14	68
Davis, S. T.	Bowgada	Perenjori	Merredin....	23	8	7	14	13	65
Browning, L. W. G.	Pithara	Royal	Bencubbin	23	8	9	13	11	64
Sutcliffe, J. & G.	Damboring....	do.	Gluclub	21	7	8	13	14	63
Helwig Bros.	Perenjori	Perenjori	Dundee	21	8	9	12	12	62
Harrington, S. C.	Damboring....	Royal	Gluclub	19	8	9	13	12	61

The Hon. T. Moore's winning crop of "Dundee" was grown on land which had previously carried York gum and jam timber. It had been ploughed in August, 1937, with a disc cultivating plough to a depth of three inches, springtyne cultivated in January, 1938, after a heavy thunderstorm, and seeded during the second week of May by means of a combined cultivator-drill. Seed and superphosphate was applied at 45 lb. and 95 lb. per acre respectively. The crop made too rapid early growth and in consequence, was lightly fed off.

Mr. O. J. Butcher's crop of "Gluclub" was grown on land that had previously been timbered with salmon gum, morrel and gimlet. The land, which has been cleared for 18 years, was cultivated in late July, 1937, with a rigid tyne cultivator to a depth of approximately three inches, and springtyne cultivated prior to seeding which was carried out during the middle of May. The rates of seed and superphosphate were 36 lb. and 112 lb. per acre respectively.

The crop of "Bencubbin" entered by Mr. R. Bradford, which was awarded third place, was on country which had previously been timbered with gimlet and been farmed for the past 17 years under a crop and fallow rotation. The land was ploughed in early June, 1937, with a disc cultivating plough to a depth of four inches and springtyne cultivated at the end of August, 1937, and again in April, 1938. It was seeded during the middle of May by means of a combined cultivator-drill with 45 lb. of seed and with an application of 90 lb. of superphosphate per acre.

ZONE 3.

Judge: N. Davenport, B.Sc. (Agric.), Agricultural Adviser.

Competitors: Dowerin, 2; Wyalkatchem, 4; Ballidu, 6; Royal, 2. Total, 14.

The rainfall recorded at centres concerned in this Zone was as hereunder:—

	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total for Year.
Dowerin	6	1	329	108	71	194	234	91	79	25	694	60	3	1,201
Wyalkatchem	45	1	116	107	39	160	239	85	74	22	619	57	5	950
Ballidu	64	9	170	134	38	125	261	118	68	23	633	80	20	1,110
Wongan Hills	5	7	151	145	76	237	214	88	124	14	753	85	....	1,146
Minnivale	67	....	171	119	40	191	235	76	69	21	632	54	....	1,043
Calingri	....	3	121	146	110	184	314	139	102	37	886	82	....	1,238
Cowcowing	23	5	119	105	32	140	180	98	48	34	532	58	5	847

The awards and particulars of the treatment received by the leading crops are as follow:—

BALLIDU AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Ackland, J. H.	Wongan Hills....	Bencubbin	27	9	9	14	13	72
Mincherton, J., Jun.	Ballidu	Gluclub	24	9	9	14	13	69
Beilby, A. H.	do.	do.	24	8	9	13	12	66
Goodie, H.	West Ballidu	Nabawa	20	9	9	14	13	65
Petchell, R.	do.	Gluclub	23	8	9	14	10	64
Thomas, W.	Ballidu	do.	21	8	9	14	11	63

The competition was won by Mr. J. H. Ackland whose crop was grown on land which had originally carried salmon gum, gimlet and mallee. It was rigid tyne cultivated at the end of June, 1937, 2½-3 inches deep, and again in July; springtyne cultivated at the end of August, again in March and April after rains. It was planted with a combined cultivator-drill with 50 lb. of seed and 120 lb. of superphosphate per acre during the second week in May, and harrowed after planting.

Mr. J. Mincherton's crop was grown on land which until six years ago had carried jam, morrel and York gum timber. It was ploughed with a disc-cultivating plough three inches deep during August; springtyne cultivated during April and seeded with a combined cultivator-drill during the second week in May, using 50 lb. of seed and 90 lb. of superphosphate per acre.

The entry of Mr. A. H. Beilby was grown on salmon gum and gimlet country. It was ploughed at the end of June, 1937, with a disc cultivating plough three to four inches deep. No further working was given until it was cultivated with a rigid-tyne implement prior to planting with a combined cultivator-drill during the second week in May, using 45 lb. of seed and 112 lb. of superphosphate per acre.

WYALKATCHEM AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts
Slocum, H. H.	Wyalkatchem....	Bencubbin	26	9	9	14	13	71
McKay, M.	Benjaberring	do.	25	9	9	14	13	70
Jones, W. W.	Cowcowing	do.	24	8	9	14	13	68
Lawrence, A. E.....	Benjaberring	Dundee	21	9	9	14	14	67

Mr. H. H. Slocum's crop which won the competition was grown on light scrub country. It was worked with a rigid-tyne cultivator in June, 1937; with a springtyne cultivator in September and again in March after rain. It was planted with a combined cultivator-drill in mid-May, using 50 lb. of seed and 100 lb. of superphosphate per acre.

A crop of "Bencubbin" entered by Mr. McKay gained second place. It was grown on mixed country, viz., York gum, salmon gum, mallee and tamma. The land was ploughed with a disc cultivating plough during August; springtyne cultivated during October, after rain in March and was then planted with a combined cultivator-drill about 1st May, using 45 lb. of seed and 120 lb. of superphosphate per acre.

Mr. W. W. Jones' crop was grown on salmon gum and mallee country. The land was broken up with a rigid tyne cultivator in June, 1937. It was cross-cultivated with a springtyne implement during August; rigid-tyne cultivated in March after rain, and then planted with a combined cultivator-drill during the first week of May, using 50 lb. of seed and 90 lb. of superphosphate per acre.

DOWERIN AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Wilmot, H. L.	Dowerin	Bencubbin	28	9	9	13	14	73
Thomas, T.	do.	do.	24	8	9	13	12	66

Mr. H. L. Wilmot's crop, which also gained second place in the Zone competition, was grown on tamma scrub plain which had been cleared for a number of years. It was ploughed with a disc-cultivating plough in early July, 1937, cultivated with a springtyne implement early in September, again after March rains and then planted with a combined cultivator-drill with rigid-tynes during the second week of May, using 45 lb. of seed and 112 lb. of superphosphate per acre. The crop was harrowed after drilling to kill weeds.

The entry of Mr. T. Thomas was grown on York gum and jam country. It was ploughed with a disc-cultivating plough early in July, 1937, ploughed back with the same implement in April and planted in mid-May with a combined cultivator-drill, using 45 lb. of seed and 90 lb. of superphosphate per acre.

ROYAL AGRICULTURAL SOCIETY.

Competitor.	Address.	Society.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total
				50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Edmonds, B. J.	Calcarra	Royal	Bencubbin	38	9	9	14	14	84
Wilmot, H. L.	Dowerin	Dowerin	do.	28	9	9	13	14	73
Ackland, J. H.	Wongan Hills	Ballidu	do.	27	9	9	14	13	72
Slocum, H. H.	Wyalkatchem	Wyalkatchem	do.	26	9	9	14	13	71
McKay, M.	Benjaberring	Wyalkatchem	do.	25	9	9	14	13	70
Mincherton, J., Jun.	Ballidu	Ballidu	Gluclub	24	9	9	14	13	69
Thomas, T.	Dowerin	Dowerin	Bencubbin	24	8	9	13	12	66
Hesford Bros.....	Minnivale	Royal	Gluclub	21	9	9	13	12	64

The crop of "Bencubbin" entered by Mr. B. J. Edmonds, which won the Zone Championship, was grown on old land which originally carried York gum and manna gum. It was ploughed with a mouldboard plough during August, 1937, and cultivated with a springtyne implement in the spring. It was seeded with a combined cultivator-drill on the 1st of May, using 60 lb. of seed and 95 lb. of superphosphate per acre.

ZONE 4.

Judge: W. M. Nunn, B.Sc. (Agric.), Agricultural Adviser.

Competitors: Nungarin, 3; Mt. Marshall, 2. Total, 5.

The rainfall for the year at Nungarin and Bencubbin was as follows:—

	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total for Year.
Nungarin	45	23	63	103	41	123	222	133	54	33	606	67	37	944
Bencubbin	34	25	65	94	112	103	171	32	36	51	505	58	1	782

The awards, and details of treatment received by the leading crops are set out hereunder:—

NUNGARIN AND EASTERN DISTRICTS AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Watson Bros.	Nungarin	Bencubbin	18	8	9	14	14	63
Creagh Bros., Ltd.	do.	Noongaar	14	8	9	14	13	58
Jolly, H. P.	do.	Bencubbin	13	9	9	14	10	55

Watson Bros.' winning crop of "Bencubbin" was grown on salmon gum country which had been ploughed in July, 1937, to a depth of 3 inches with a disc plough. It was springtyne cultivated in October, again in March, 1938, after heavy rain and then seeded during the last week in April; the rates of seed and superphosphate being 45 lb. and 90 lb. per acre, respectively.

The crop of "Noongaar" entered by Creagh Bros., Ltd., was grown on salmon, gimlet and mallee country which had been ploughed in July, 1937, with a disc plough, springtyne cultivated in August, 1937, and scarified after rain in March and May, 1938. Seeding took place during the second week in June, seed and superphosphate being applied at the rates of 45 lb. and 112 lb. per acre, respectively.

MT. MARSHALL AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Gilham, F.	Bencubbin	Bencubbin	16	7	9	12	12	56
Hopwood, B. W. G.	do.	do.	11	9	9	14	11	54

The winning crop of "Bencubbin" entered by Mr. F. Gilham was on land which had originally been timbered with salmon gum. It was cultivated in June, 1937, with a rigid-tyne cultivator to a depth of 3 inches, and again during August, 1937. During mid-April seed and superphosphate were applied at the rates of 40 lb. and 90 lb., respectively, by means of a combined cultivator-drill.

ROYAL AGRICULTURAL SOCIETY.

Competitor.	Address.	Society.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Watson Bros.	Nungarin	Nungarin	Bencubbin	18	8	9	14	14	63
Creagh Bros., Ltd.	do.	do.	Noongaar	14	8	9	14	13	58
Gilham, F.	Bencubbin	Mt. Marhsall	Bencubbin	16	7	9	12	12	56
Hopwood, B. W. G.	do.	do.	do.	11	9	9	14	11	54

ZONE No. 5.

Judge: W. M. Nunn, B.Sc. (Agric.), Agricultural Adviser.

Competitors: Bruce Rock, 3; Royal, 1. Total, 4..

The rainfall recorded at the centres concerned was as follows:—

	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total for Year.
Bruce Rock	70	9	129	32	84	169	292	90	81	74	790	32	2	1,064
Kelleberrin	41	1	114	53	69	172	282	74	57	113	767	29	10	1,015

The Judge's awards, together with the details of the treatments received, are set out in the following table:—

BRUCE ROCK AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Ellis, E. G. & M. P.	Bruce Rock	Gluclub	25	9	8	14	13	69
Wilkins, H. W.	do.	Bencubbin	21	9	8	14	12	64
Pimlott, S H.	Kwolyin	do.	21	8	9	13	11	62

Messrs. E. G. and M. P. Ellis' winning crop of "Gluclub" was on salmon gum, gimlet and jam country which had been ploughed early in July with a disc plough to an approximate depth of 4 inches. It was harrowed in August, 1937, springtyne cultivated in September, 1937, and April, 1938, and seeded during the first week of May, when 50 lb. seed and 90 lb. superphosphate per acre were applied.

The second award was given to a crop of "Bencubbin" entered by Mr. H. W. Wilkins and grown on salmon gum, gimlet and York gum country. The land was ploughed in July, 1937, with a disc plough and rigid-tyne cultivated in August, September, and April, 1938, just prior to seeding. Seed and superphosphate were applied at the rates of 50 lb. and 84 lb. per acre, respectively.

ROYAL AGRICULTURAL SOCIETY

Competitor.	Address.	Society.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Ellis, E. G. & M. P.	Bruce Rock	Bruce Rock	Gluclub	25	9	8	14	13	69
Diver, L. C.	Kellerberrin	Royal	Bencubbin	22	8	9	14	13	66
Wilkins, H. W.	Bruce Rock	Bruce Rock	do.	21	9	8	14	12	64

Mr. L. C. Diver's crop of "Bencubbin" was on salmon gum and gimlet country which had been cultivated in June, 1937, with a springtyne implement. It was rigid-tyne cultivated in July, and cultivated with a springtyne cultivator in August and prior to seeding in May. Rates of seed and superphosphate were 60 lb. and 80 lb. per acre, respectively.

ZONE 7.

Judge: A. S. Wild, B.Sc. (Agric.), Agricultural Adviser.

Competitors: Kulin, 13; Kukerin, 11; Karlgarin, 9; Lake Grace, 10. Total, 43.

The rainfall recorded during the year at stations in this zone was as follows:—

——	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total for Year.
Karlgarin	96	15	140	19	99	200	207	89	104	90	789	53	5	1,117
Kondinin	97	39	183	28	102	140	243	115	79	28	707	44	6	1,104
Kulin	40	13	251	24	112	166	311	135	138	73	935	52	34	1,349
Lake Grace	71	....	270	30	68	155	219	128	118	92	780	51	28	1,230
Kukerin	188	....	158	42	95	169	220	170	143	92	889	48	16	1,341

The awards made are set out below:—

KARLGARIN AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Free dom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Finemore, A.	Karlgarin	Bencubbin	31	9	9	12	13	74
Richter Bros.	do.	do.	28	9	9	13	13	72
Cowling, E. W.	Sth. Karlgarin	do.	27	9	8	13	13	70
Marshall, H. J.	Hyden	do.	24	9	9	14	13	69
Biglin, E. J.	Karlgarin	do.	24	8	9	14	13	68
Grieves, H. F.	Hyden	do.	24	9	8	12	13	66
Richter, B. G.	Karlgarin	Gluyas Early	23	9	7	14	13	66
Medcalf, C. W.	do.	Bencubbin	23	8	9	12	13	65
James, S. W.	do.	do.	17	9	9	14	12	59

The winning crop of "Bencubbin" of Mr. A. Finemore was grown on salmon gum, mallee and gimlet country which had been cropped for many years and which was rigid-tyne cultivated 3-4 inches deep in early August. It was cultivated with the same implement 3 inches deep in September, and again early in March, and planted with a combined cultivator-drill the second week in May. Fifty pound of seed and 125 lb. superphosphate were applied per acre.

Messrs. Richter Bros.' crop of "Bencubbin" was grown on a similar type of land which had been mouldboard ploughed 3 inches deep in July. The ploughed land was rigid-tyne cultivated in late August and early March and the crop was planted the second week in May with a combined cultivator-drill. The respective rates of application of seed and superphosphate were 50 lb. and 110 lb. per acre.

Mr. E. W. Cowling's entry was also of the variety "Bencubbin." The land on which the crop was planted was salmon gum and jam country which had been ploughed 3 inches deep with a disc implement the previous July, and which received a springtyne cultivation just prior to seeding, which took place in mid-May. Seed and superphosphate were applied at the respective rates of 50 and 90 lb. per acre.

KULIN AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Evans, H. R.	Kulin Rock	Bencubbin	35	9	8	14	14	80
Clayton, R., & Sons	Jitarning	do.	31	9	9	14	14	77
Parker, C. W.	Jilakin	do.	31	9	8	14	14	76
Wilson, J. C.	Kulin	do.	32	9	8	13	13	75
Freebairn, F. S.	Kulin Rock	do.	29	9	8	13	14	73
Ryan, M.	Kulin	Gluclub	28	9	9	13	13	72
Roberts, J. F.	Kulin Rock	Bencubbin	28	8	9	13	13	71
Smith & Riseborough	Jitarning	Gluyas Early	25	9	9	14	14	71
Bowey, P. J.	Kulin	Ford	26	9	8	13	14	70
Meikle, P.	Kulin Rock	Sword	28	7	8	13	12	68
Parker, J. W.	Kulin	Gluclub	27	7	8	13	13	68
Gray, J. S.	Jilakin	do.	23	9	8	13	13	66
Stubbs, W.	Kondinin	Bencubbin	24	8	9	12	13	66

This competition was won by an entry of the variety "Bencubbin" submitted by Mr. H. R. Evans. The land was salmon gum, gimlet and York gum country which had been ploughed 3½ inches deep with a mouldboard plough in early June, cultivated with a rigid-tyne cultivator in early September and disc cultivated 2 inches deep prior to seeding. The crop was sown the first week in May with a disc drill with light harrows attached, 65 lb. of seed and 90 lb. of superphosphate being applied per acre. The crop was heavily fed off by sheep until late July.

Messrs. R. Clayton & Sons' crop of "Bencubbin" was grown on York gum and jam country, which was ploughed 2½ inches deep with a mouldboard plough in July. It was rigid-tyne cultivated in early August, springtyne cultivated in September, and again in April, and the crop was planted with a combined cultivator-drill in mid-May. Forty-two pound of seed and 90 lb. of superphosphate were applied per acre.

Mr. C. W. Parker's crop of "Bencubbin" was grown on jam, York gum, salmon gum and morrel country which had been ploughed with a disc implement 3 inches deep in July. This was rigid-tyne cultivated in October, springtyne cultivated in March and the crop was planted the first week in May with a combined cultivator-drill, 50 lb. of seed and 94 lb. of superphosphate being used per acre.

LAKE GRACE AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Garard, T.	Pingaring	Bencubbin	27	9	8	13	14	71
Coad, H. J.	Lake Grace	Gluclub	28	8	8	13	13	70
Curwood, W.	Lake Biddy	Bencubbin	27	8	9	11	14	69
English, I. P.	Lake Grace	Gluclub	24	9	8	14	14	69
Kean Bros.	Pingaring	Bencubbin	25	9	9	12	13	68
Bishop, S. J.	Lake Grace	do.	24	9	9	12	13	67
Fry, E. H.	Nth. Lake Grace	Gluclub	23	9	8	13	14	67
Curwood, D. J. V.	Lake Biddy	do.	25	8	8	13	12	66
Kay, W.	Lake Grace	Bencubbin	23	8	8	12	14	65
Hadden, R. T.	Pingaring	Gluclub	23	8	8	12	13	64

The winning crop of Mr. T. Garard, was of the variety "Bencubbin" grown on salmon gum and mallee country which had been ploughed 4 inches deep with a disc plough in July. It was springtyne cultivated in September, again in April and planted with a combined cultivator drill during the second week in May. Sixty pounds of seed and 90 lb. of superphosphate per acre were used.

Mr. H. J. Coad's crop of "Gluclub" was planted on salmon gum, gimlet and morrel country which had been ploughed 3 inches deep with a disc plough in July, rigid-tyne cultivated in September and again in March. It was planted during the third week in April with a combined cultivator-drill, and 45 lb. of seed and 120 lb. of superphosphate were used per acre.

Mr. W. Curwood's crop of "Bencubbin" was grown on salmon gum, morrel, gimlet and boree country. This was disc ploughed 3 inches deep in July. Half the area was springtyne cultivated and the remainder disc-cultivated 2 inches deep in August. It was rigid-tyne and also springtyne cultivated just prior to seeding, which took place during the first week in May. The rates of seed and superphosphate were 50 lb. and 90 lb. respectively per acre.

KUKERIN AGRICULTURAL SOCIETY

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts
Bennett, R. G.	Dumbleyung	Gluclub	38	8	8	13	14	81
Bahr, Ron	Merilup	Bencubbin	30	9	9	13	14	75
English, A. R.	Kukerin	do.	30	9	9	13	13	74
Taylor, A. J.	Dumbleyung	Gluyas Early	28	9	9	13	14	73
Bairstow, F.	Moulyinning	Gluclub	27	9	9	14	13	72
Faulkner, W. J.....	North Kukerin	Bencubbin	30	9	7	13	13	72
Joyce, F.	do.	do.	27	9	8	13	14	71
English, J. C.	Merilup	do.	26	8	8	14	13	69
Kellow, J.	North Kukerin	Dundee	21	9	7	14	14	65
Nenke, C. E.	Kukerin	Merredin	20	9	8	14	14	65
Gard, Wm.	Merilup	Bencubbin	23	8	7	13	13	64

Mr R. G. Bennett won this completition with a crop of "Gluclub" planted on morrel country. This was ploughed with a mouldboard plough to a depth of 3 inches in August, springtyne cultivated in September and again in March. It was planted in mid-May with a combined cultivator-drill, 60 lb. of seed and 112 lb. of superphosphate being used per acre.

A crop of "Bencubbin" entered by Mr. R. Bahr gained second place. This was grown on York gum and morrel country which was ploughed with a mouldboard plough 3-4 inches deep in August. In September it was rigid-tyne cultivated, and springtyne cultivated prior to seeding which was carried out during the fourth week in May, using a combined cultivator-drill, 45 lb. of seed and 40 lb. of superphosphate being applied per acre.

Mr. A. R. English's crop of "Bencubbin" was grown on York gum and mallee country which was rigid-tyne cultivated 3-4 inches deep late in June. It was culti-

vated 3-4 inches deep late in June. It was cultivated with the same implement in September and March and planted with a combined cultivator-drill in mid-May. Forty-eight pounds of seed and 90 lb. of superphosphate were used per acre.

ROYAL AGRICULTURAL SOCIETY.

Competitor.	Address.	Society.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts
Bennett, R. G.	Dumbleyung	Kukerin	Gluclub	38	8	8	13	14	81
Evans, H. R.	Kulin Rock....	Kulin	Bencubbin	35	9	8	14	14	80
Clayton, R., & Sons	Jitarning	do. ...	do.	31	9	9	14	14	77
Bahr, Ron. ..	Merilup ..	Kukerin	do.	30	9	9	13	14	75
Finemore, A. ..	Karlgarin ..	Karlgarin	do.	31	9	9	12	13	74
Richter Bros. ..	do.	do	do.	28	9	9	13	13	72
Garard, T. ..	Pingaring	Lake Grace....	do.	27	9	8	13	14	71
Coad, H. J.	Lake Grace....	Lake Grace....	Gluclub	28	8	8	13	13	70

ZONE 8.

Judge: G. L. Throssell, Dipl. Agric., Agricultural Adviser.

Competitors: Quairading, 4; Wickepin, 11; Gnowangerup, 10; Royal, 6. Total, 31.

The rainfall for the year at centres concerned in Zone 8 is set out below.

	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total for Year.
New Norcia	4	2	183	182	105	274	325	196	143	68	1,111	71	5	1,558
Muresk	16	11	144	105	104	188	439	133	101	34	955	59	55	1,345
York	24	12	226	95	162	217	416	159	145	52	1,151	60	3	1,571
Quairading	112	23	303	49	104	173	375	110	99	64	925	39	18	1,469
Wickepin	11	....	202	58	128	101	375	140	137	51	992	63	18	1,344
Noman's Lake	9	1	173	57	192	161	382	226	181	80	1,222	48	16	1,526
Broomehill	9	3	151	46	126	180	290	153	161	64	974	29	25	1,237
Gnowangerup	13	....	129	35	105	178	238	144	165	89	919	9	19	1,124
Borden	58	....	111	46	99	154	137	182	78	48	698	6	14	933

The awards are set out below:—

QUAIRADING AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Hull, W.	Quairading	Bencubbin	29	8	9	13	13	72
Powell, G. J.	do.	Ranee	26	9	9	14	13	71
Forrest, A.	do.	Gluclub	27	9	9	12	13	70
Campbell, L. T.....	Sth. Caroling	Sword	25	8	9	13	12	67

The winning crop entered by Mr. W. Hull was a crop of "Bencubbin" grown on land which originally carried mallee and scrub and which had been cropped three times previously. It was disc ploughed to three inches deep in September and scrub raked and harrowed in October and sown with a sunder-seeder on 28th April, 48 lbs. seed and 130 lbs. superphosphate being applied.

The entry of Mr. G. J. Powell, which gained second place, was of the variety "Ranee." The original timber was jam. The land was cultivated with a rigid-tyne cultivator in July and August to a depth of 3 inches, again in September with the same implement, and springtyne cultivated in March. The crop was sown in the middle of May, seed and superphosphate being applied at the rate of 45 lbs. and 112 lbs. respectively.

Mr. A. Forrest's crop of "Gluclub" was on jam and York gum country which was disc ploughed 4 inches deep at the end of June and springtyne cultivated in September and April. It was seeded during the third week in May, seed and superphosphate being sown at the rate of 48 lbs. and 122 lbs. respectively.

WICKEPIN AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Fleay, E. H, & Son	Wickepin	Bencubbin	29	9	8	14	13	73
Doncan, E. E.	do.	do.	29	8	8	14	13	72
McDougall, R.	do.	do.	28	8	9	14	12	71
Dalton, L. C.	do.	do.	28	8	8	14	13	71
Fleay Bros.	do.	Totadgin	27	9	9	13	13	71
McDougall, K.	Tinkurrin	Waratah	28	8	8	14	12	70
Hosken Bros.	Wickepin	Bencubbin	26	9	8	14	13	70
McDougall, C.	Tinkurrin	Sword	26	9	8	13	13	69
McDonald, W. G.	Noman's Lake	do.	24	9	9	13	14	69
McDougall, M.	Tinkurrin	Dundee	23	8	8	13	12	64
Cockram & Ballard	do.	Merredin	23	7	8	13	13	64

Messrs. E. H. Fleay & Son won this competition with a crop of "Bencubbin" grown on country which originally carried York gum, morrel and jam and which had been cropped four times previously. The land was ploughed three inches deep with a disc-cultivating plough in July and springtyne cultivated in March. It was planted during the middle of May and 50 lbs. of seed and 70 lbs. of superphosphate were applied per acre.

Mr. E. E. Doncan's entry which gained second place was also the "Bencubbin" variety. The land, which was jam and York gum country, had been cropped three times and was ploughed with a mould-board plough in August three to four inches deep and springtyne cultivated in September and March. Fifty-two pounds of seed and 90 lb. of superphosphate were applied per acre.

Mr. R. McDougall's crop of "Bencubbin" was grown on York gum, jam, morrel and salmon gum country. The land was ploughed with a mouldboard plough in August, three inches deep, and springtyne cultivated in October, the end of March and mid-May and was planted the third week in June. Seed and superphosphate were applied at the rate of 50 lbs. and 90 lbs. per acre respectively.

GNOWANGERUP AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Dolley, S. H. G.....	Jacketup	Bencubbin	35	9	9	14	13	80
Wright, E. H.	Pallinup	do.	34	9	8	14	13	78
Thomson & Hill	Jacketup	Rajah	31	9	9	13	14	76
Wellard & Wellard	Gnowangerup....	Bencubbin	31	9	9	14	12	75
Formby, R., & Co.	do.	do.	29	9	9	14	13	74
Davis, N. P.	do.	Dundee	27	9	9	13	13	71
Stewart, W. B.	Borden	Gallipoli	26	9	9	13	13	70
Cockram, C. E.	Pallinup	do.	27	8	9	13	12	69
McDonald, J. V. & A. R.	Gnowangerup....	Ghandi	25	9	9	13	13	69
House, D. K.	do.	Gallipoli	25	8	9	13	12	67

Mr. S. H. G. Dolley's crop of "Bencubbin" which won the competition was grown on York gum, salmon gum and morrel country which had been ploughed with a mouldboard plough 3½ inches deep in July and early August, and cultivated with a springtyne cultivator in September, April and early May; the crop was sown the third week in May with a combined cultivator-drill, 54 lbs. seed and 135 lbs. of superphosphate being used per acre.

Mr. E. H. Wright's entry of "Bencubbin" was planted on York gum, whitegum and manna country which was mould-board ploughed 3½ inches deep in August and springtyne cultivated in October, March and April. It was sown at the end of May, 65 lbs. of seed and 90 lbs. superphosphate being applied per acre.

Messrs. Thomson & Hill's crop of "Rajah" was grown on salmon and manna gum country which was ploughed to a depth of 3½ inches with a mould-board implement in July and cultivated with a springtyne cultivator in September,

March and May. It was planted at the rate of 45 lbs. of seed and 112 lbs. of superphosphate per acre in mid June.

ROYAL AGRICULTURAL SOCIETY.

Competitor.	Address.	Society.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture	Evenness of Growth.	Total.
				50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Batchelor, A. J.	Broomehill	Royal	Bencubbin	37	9	9	13	13	81
Dolley, S. H. G.	Jacketup	Gnowangerup	do.	35	9	9	14	13	80
Burges, W. G.	Wilberforce	Royal	Dundee	36	8	9	13	13	79
Wright, E. H.	Pallinup	Gnowangerup	Bencubbin	34	9	8	14	13	78
Prideaux, J. S.	Nenan's Lake	Royal	do.	30	9	9	14	14	76
Boyle, T. W.	York	do.	do.	30	9	9	14	13	75
Taylor, C.	Broomehill	do.	do.	30	9	9	13	13	74
Fleay, E. H., & Son	Wickepin	Wickepin	do.	29	9	8	14	13	73
Hull, W.	Quairading	Quairading	do.	29	8	9	13	13	72
Duncan, E. E.	Wickepin	Wickepin	do.	29	8	8	14	13	72
Powell, G. J.	Quairading	Quairading	Ranee	26	9	9	14	13	71
Grove, F. P.	New Norcia	Royal	Bencubbin	22	9	7	14	13	65

The crop which won the Home Championship was entered by Mr. A. J. Batchelor of Broomehill and was of the variety "Bencubbin." This had been grown on York gum, white gum, marri and jam country, which had been cropped once previously. It was ploughed with a mouldboard plough three inches deep in early August, springtyne cultivated at the end of September and again prior to seeding. It was planted with a combined cultivator-drill, seed and superphosphate being applied at the rates of 60 lbs. and 90 lbs. per acre respectively.

ZONE 9.

Judge—A. S. Wild, B.Sc.(Agric.), Agricultural Adviser.

The four competitors in this zone all entered through the Phillips River Agricultural Society.

The rainfall recorded at Ravensthorpe and Mt. Short was as follows:—

					Growing Period.							Total for Year.
	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	
Ravensthorpe	236	24	93	118	135	252	206	133	76	60	862	35	40	1,408
Mt. Short	265	29	99	110	100	246	204	112	91	73	826	52	43	1,424

The awards are set out in the following table: —

PHILLIPS RIVER AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield, 1 point per bush.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Campbell, J.	Mt. Short	Bencubbin	24	9	9	14	14	70
Bebbington, F. J. S.	Ravensthorpe....	Totadgin	23	9	9	14	13	68
Daw, F. E.	do.	Nabawa	24	9	8	13	12	66
Chambers Bros.....	do.	Ford	16	9	8	12	12	57

Mr. J. Campbell's winning crop of "Bencubbin" was grown on jam, salmon gum and mallee country which had been cropped for many years. It was ploughed with a mouldboard plough 3½-4 inches deep in June, 1937, springtyne cultivated in September and prior to planting. The crop was sown the first week in May, 45 lbs. of seed and 85 lbs. of superphosphate being applied.

Mr. F. J. S. Bebbington's crop of "Totadgin," which gained second place, was grown on mallee and salmon gum country which was ploughed 3 inches deep late in August with a disc plough and springtyne cultivated shortly after. It was planted the fourth week in May, 45 lbs. of seed and 90 lbs. of superphosphate being used per acre.

The crop of "Nabawa" entered by Mr. F. E. Daw, which was placed third, was grown on mallee country. This was ploughed in August 2½ to 3 inches deep

with a disc implement and rigid-tyne cultivated prior to seeding, which was carried out during the fourth week of May, 45 lbs. and 90 lbs. being the respective rates of seed and superphosphate applications.

ENTRIES.

Entries totalling 104 were received from 17 District Agricultural Societies. The Royal Agricultural Society received 16 entries direct, making the total number of competitors 120.

The following table shows the number and the average yield obtained each year since the competition was inaugurated:—

Year.	Number of District Agricultural Societies Competing.	Number of Competitors.	Average Yield of Competitors.	Average Yield for State.
			Bushel	Bushel
1921	...	15	25	10·4
1922	...	32	24	8·9
1923	12	82	29	11·4
1924	15	70	31	12·8
1925	13	59	22·5	9·7
1926	11	99	24·5	12·0
1927	10	100	26·9	12·1
1928	13	114	22·5	10·1
1929	12	156	21·7	11·0
1930	15	165	27·4	13·3
1931	13	110	27·4	13·1
1932	17	168	29·3	12·3
1933	17	130	27·2	11·7
1934	17	114	26·8	9·8
1935	16	97	24·8	9·2
1936	12	80	21·0	8·4
1937	15	138	25·7	11·9
1938	17	120	26·3	10·6*

* Estimate.

VARIETIES.

The most outstanding variety this year was the standard midseason maturing variety "Bencubbin," which comprised 62 of the 120 competing crops. This variety also won fourteen of the seventeen district competitions as well as five of the eight zone championships, while two of the three crops which won the special prize for the highest calculated bushel yield per acre, viz. 38 bushels, were also of the same variety—the other being "Gluclub." Twenty-one entries were of the variety "Gluclub" which was placed first in two district competitions and two zone championships. The varieties "Merredin" and "Dundee" each won a district competition and the former one zone championship.

The details concerning the individual varieties were as follows:—

Bencubbin (62); Gluclub (21); Dundee (8); Merredin (6); Sword (4); Nabawa, Gallipoli and Gluyas Early (3); Ford, Totadgin and Ranee (2); and Noongaar, Waratah, Rajah and Ghandi (1). Total, 120.

YIELDS.

The special prize of £5 5s., for the competitor obtaining the highest calculated yield per acre was divided among three competitors, viz., Messrs. J. A. Tonkin & Sons, Coomberdale; B. J. Edmonds, Calcarra; and R. G. Bennett, Dumbleyung, who each obtained a yield of 38 bushels per acre.

The winners of this prize since 1925 are:—

	Bush. per acre.
1925—Hebiton & Sons, Three Springs—Nabawa	34
1926—Cumming Bros., Carnamah—Yandilla King	38
1927—A. W. Parkinson, Gnowangerup—Yandilla King ...	40
1928—A. W. Parkinson, Gnowangerup—Yandilla King ...	40
1929—C. E. Cockram, Pallinup—Yandilla King	46
1930—C. Smith & Sons, Yarding—Gluclub	43
1931—H. O. Beeck, Gnowangerup—Yandilla King	42
1932 F. S. Freebairn, Jilakin—Gluclub	47
1933—D. Davis, Gnowangerup—Bencubbin	43
1934—C. E. Cockram, Pallinup—Free Gallipoli	40
1935—E. Davis, Gnowangerup—Bencubbin	41
1936—C. E. Cockram, Pallinup—Free Gallipoli	30
1937 A. R. English, Kukerin—Bencubbin	41
1938 A. J. Tonkin & Sons, Coomberdale—Bencubbin ...	38
1938 B. J. Edmonds, Calcarra—Bencubbin	38
1938 R. G. Bennett, Dumbleyung—Gluclub	38

Of the 120 entries in this year's competition, sixty-three were calculated to yield 24 to 30 bushels; sixteen 31 to 36 bushels; three 37 bushels, and three 38 bushels per acre.

The list of the competitors who obtained 30 bushels and over is given below:—

Zone.	Competitor.	Address.	Society.	Variety.	Estimated Yield.
1	Tonkin, J. A., & Sons ...	Coomberdale...	Moora ...	Bencubbin ...	38
3	Edmonds, B. J. ...	Calcarra ...	Royal ...	do. ...	38
7	Bennett, R. G. ...	Dumbleyung...	Kukerin ...	Gluclub ...	38
1	Adams, R. H.	Bindi Bindi...	Moora ...	Ranee ...	37
1	Isbister, J.	Moora ...	do. ...	Dundee ...	37
8	Batchelor, A. J. ...	Broomehill ...	Royal ...	Bencubbin ...	37
1	Bothe, B. D.	Coorow ...	do.	do. ...	36
8	Burges, W. G.	Wilberforce ...	do.	Dundee ...	36
7	Evans, H. R.	Kulin Rock ...	Kulin ...	Bencubbin ...	35
8	Dolley, S. H. G. ...	Jacketup ...	Gnowangerup	do. ...	35
8	Wright, E. H.	Pallinup ...	do. ...	do. ...	34
1	Hockridge, W. J. ...	Moora ...	Moora ...	Merredin ...	33
1	Franklin, E. W. ...	Three Springs	Three Springs	Bencubbin ...	33
1	Olden, S. R.	do. ...	do. ...	do. ...	32
1	Davey, E.	Arrino ...	do. ...	Gluclub ...	32
7	Wilson, J. C.	Kulin ...	Kulin ...	Bencubbin ...	32
2	Moore, Hon. T. ...	Indarra ...	Royal ...	Dundee ...	31
7	Finemore, A.	Karlgarin ...	Karlgarin ...	Bencubbin ...	31
7	Clayton, R., & Sons ...	Jitarning ...	Kulin ...	do. ...	31
7	Parker, C. W.	Jilakin ...	do.	do. ...	31
8	Thomson & Hill ...	Jacketup ...	Gnowangerup	Rajah ...	31
8	Wellard & Wellard ...	Gnowangerup	Gnowangerup	Bencubbin ...	31
1	Williamson, A. M. ...	Three Springs	Three Springs	Nabawa ...	30
7	Bahr, Ron.	Merilup ...	Kukerin ...	Bencubbin ...	30
7	English, A. R.	Kukerin ...	do. ...	do. ...	30
7	Faulkner, W. J. ...	Nth. Kukerin	do. ...	do. ...	30
8	Prideaux, J. S. ...	Noman's Lake	Royal ...	do. ...	30
8	Boyle, T. W.	York	do.	do. ...	30
8	Taylor, Cyril	Broomehill ...	do.	do. ...	30

The high yields obtained by many of the individual competitors and an average yield of 26.3 bushels per acre for the whole competition are distinctly creditable in a season such as has been experienced. They indicate too, that the crop competitions are achieving their objects in raising the standard of farming methods of the State.

LOCAL CROP COMPETITIONS, 1938.

I. Thomas, Superintendent of Wheat Farming.

In addition to the 50 Acre Crop Competitions conducted by the Royal and District Agricultural Societies under the Zone System several separate competitions were conducted.

The Bruce Rock, Karlgarin, Koorda and Merredin Agricultural Societies conducted Fallow and Crop Competitions, and the Toodyay Agricultural Society and the Wialki Branch of the Wheat Growers' Union each conducted a 50 Acre Crop Competition under the same conditions as govern the Royal Agricultural Society's competition.

The particulars of the respective competitions are as follow:—

BRUCE ROCK AGRICULTURAL SOCIETY.

50 Acre Fallow and Crop Competition.

Judge:—W. M. Nunn, B.Sc. (Agric.), Agricultural Adviser.

The rainfall recorded at Bruce Rock during the year was as follows:—

					Growing Period.									Total for
Station.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Year.
Bruce Rock	70	9	129	32	84	169	292	90	81	74	790	32	2	1,064

The judge's awards are shown in the following table:—

BRUCE ROCK AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total for Crop.	Total for Fallow*.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.	100 pts.	200 pts.
Fuchsbichler, M.	Bruce Rock....	Totadgin....	17	9	9	13	14	62	86	148
Buller, A. M.	do.	Dundee	19	8	9	14	14	64	83	147

* Fallow Section judged in March, 1938.

The combined crop and fallow competition was won by Mr. M. Fuchsbichler, whose competing area was salmon gum and gimlet country which had been cropped for many years and which had been cultivated to a depth of 3½ inches in June, 1937, with a rigid-tyne cultivator. It was cultivated again with the same implement in August and spring-tyne cultivated in September and after rain in April. The crop was of the variety "Totadgin" and was planted during the fourth week in May, the rates of seed and superphosphate being respectively 45 lbs. and 120 lbs. per acre.

Mr. A. M. Buller's entry was on a similar type of country that had also been cultivated 3 inches deep in June, 1937, with a rigid-tyne cultivator. Further cultivations were given with the same implement in August and November and the variety "Dundee" was sown the first week in May. 45 lbs. of seed and 90 lbs. of superphosphate were used per acre.

KARLGARIN AGRICULTURAL SOCIETY.

Fallow and Crop Competition.

Judge: A. S. Wild, B.Sc. (Agric.), Agricultural Adviser.

The rainfall recorded at Karlgarin during the year was as follows:—

					Growing Period.									Total for
Station.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Year.
Karlgarin	96	15	140	19	99	200	207	89	104	90	789	53	5	1,117

The Judge's awards are shown in the following table:—

KARLGARIN AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield.	Freedom from Weeds.	Freedom from Disease.	Freedom from Injurious Insects.	Evenness of Growth.	Total for Crop.	Total for Fallow.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.	100 pts.	200 pts.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The fallow competition was judged in February, 1938.

The competition was won by Mr. A. Finemore. This entry originally carried salmon gum, mallee and gimlet timber and had been rigid-tyne cultivated 3-4 inches deep in early August, 1937, and worked 3 inches deep with the same implement in September, and again in early March. The crop which was of the variety "Bencubbin" was planted with a combined cultivator-drill during the second week in May, seed and superphosphate being applied at the rates of 50 lbs. and 125 lbs. respectively.

Messrs. Rodney Bros. gained second place with a crop of "Bencubbin" grown on salmon gum, mallee and gimlet country. This had been ploughed in July with a mouldboard plough 4 inches deep, and subsequently was rigid-tyne cultivated 3 inches deep late in August and again in early March. The crop was planted during the second week in May, 50 lbs. of seed and 110 lbs. superphosphate being used per acre.

Mr. E. J. Rigby entered a crop of "Bencubbin," grown on salmon gum, gimlet and mallee country. This was mouldboard ploughed 3 inches deep in July and rigid-tyne cultivated in mid-August and March. It was planted with a combined cultivator-drill during the fourth week in April, and 45 lbs. of seed and 90 lbs. superphosphate per acre were applied.

KOORDA AGRICULTURAL SOCIETY.

Judge:—W. M. Nunn, B.Sc. (Agric.), Agricultural Adviser.

The rainfall recorded at Booralaming during the year was as follows:—

	Growing Period.												Total for Year.
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The Judge's awards and pertinent details of the competitors' work are as follows:—

KOORDA AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield.	Freedom from Weeds.	Freedom from Disease.	Freedom from Injurious Insects.	Evenness of Growth.	Total for Crop.	Total for Fallow*.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.	100 pts.	200 pts.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* The Fallow Competition was judged on 1st March, 1938.

There were five competitors in the fallow competition but only two of these entered the crop competition.

The combined fallow and crop competition was won by Mr. R. T. Best, whose competing area was salmon gum and gimlet country. This was ploughed 5 inches deep with a mouldboard plough at the end of June, 1937. It was disc cultivated in

September and springtyne cultivated in March. The variety "Bencubbin" was planted on 20th April and the rates of application of seed and superphosphate were 50 lbs. and 90 lbs. per acre, respectively.

Mr. H. Sharman entered a similar class of country and used a rigid-tyne cultivator for the initial operation, working to a depth of 3 inches. It was cultivated with the same implement in August, springtyne cultivated in December, and rigid-tyne cultivated in April, both the December and April workings being done when the mulch was dry. Seeding took place during the second week in May, and 60 lbs. of seed and 90 lbs. of superphosphate were sown per acre.

MERREDIN AGRICULTURAL SOCIETY.

Judge:—W. M. Nunn, B.Sc. (Agric.), Agricultural Adviser.

The rainfall recorded at Burracoppin, Merredin and Belka during the year is shown in the following table:—

Station.	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total for Year.
Burracoppin	50	....	62	60	73	88	186	78	56	19	500	58	17	747
Merredin	57	3	89	78	85	168	184	87	113	30	667	49	21	964
Belka	97	....	81	59	54	172	288	80	81	37	712	37	11	997

The awards and cultural details are shown below:—

MERREDIN AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total for Crop.	Total for Fallow*.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.	100 pts.	200 pts.
McPharlin, E. P. S. & Sons	South Burracoppin	Bencubbin	17	9	9	14	12	61	88	149
Harling, H. H.	Belka	do.	18	8	9	13	12	60	85	145
Flockart, I. H.	Merredin	do.	16	7	9	14	12	58	82	140

* The Fallow Competition was judged on 17th March, 1938.

The competition was won by Messrs. E. P. S. McPharlin & Sons, of South Burracoppin. Their competing area was salmon gum and mallee country which had been cultivated 2½ inches deep the second week in June, 1937, with a rigid-tyne cultivator. It received two further workings with the same implement in August and September. The variety "Bencubbin" was sown the third week in May at the rate of 45 lbs. per acre with 120 lbs. of superphosphate per acre.

Mr. H. H. Harling, of Belka, was awarded second place. A competing area of a similar type of country was entered by this competitor and he also used a rigid-tyne cultivator for the initial operation, working to a depth of 2½-3 inches. It was rigid-tyne cultivated in August and spring-tyne cultivated in November. The variety "Bencubbin" was sown in mid-May, the rates of application of seed and superphosphate being 45 lbs. and 112 lbs. respectively.

Mr. I. H. Flockart's competition crop was on salmon gum and gimlet country which was rigid-tyne cultivated 2½-3 inches deep in July and worked with the same implement in January after rain. The variety "Bencubbin" was planted late in May and 45 lbs. of seed and 112 lbs. of superphosphate were used per acre.

TOODYAY AGRICULTURAL SOCIETY.

Judge:—F. V. Knapp, M.D.A. (Hons.), B.Sc. (Agric.), Agricultural Adviser.

The rainfall recorded at the centre concerned during the growing period was as follows:—

Station.	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total for Year.
Toodyay	1	7	124	116	112	261	478	192	159	70	1,272	69	17	1,606

The awards and details of the treatment received by the leading crops are set out below:—

TOODYAY AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield 1 point per bus.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Ludemann, D.	Wattening	Bencubbin	44	9	9	14	14	90
Hayes, E. D. P.	Toodyay	Ghurka	42	9	9	14	13	87
Lloyd Bros.	Culham	Nabawa	41	9	9	14	14	87
Hayes, E. D. P.	Toodyay	Ghurka	40	9	9	13	13	84
Millington, A.	Wattening	Bencubbin	39	9	8	14	14	84
Lloyd Bros	Culham	Bencubbin	43	8	8	9	13	81
Stevenson, K. J. O.	Wattening	Lotts	34	9	7	13	12	75
Hammersley, V. & Son	Culham	Dundee	32	9	7	14	13	75
Drake-Brockman, R.	Toodyay	Ghurka	28	9	9	13	13	72
Stevenson, K. J. O.	Wattening	Wannon	32	8	7	12	12	71
Wroth, P.	Bejoording	Bena	30	8	7	13	13	71
Clarkson, J. W.	Toodyay	Bena	26	7	8	13	12	66
Hamersley, V. & Son	Culham	Bena	25	8	6	14	12	65
Drake-Brockman, R.	Toodyay	Bena	26	7	7	12	12	64

Mr. Ludemann's winning crop of "Bencubbin" was on light country which had been cleared for a number of years and ploughed 4 inches deep in late August, 1937, with a scrub-plough to deal with regrowth of shrubs. It received no further cultivation until it was seeded in mid-April by means of a combined cultivator-drill, seed and superphosphate being applied at the rate of 48 lbs. and 120 lbs per acre, respectively.

The second prize was awarded to Mr. E. D. P. Hayes' crop of "Ghurka" which was grown on land which originally carried York gum. It had been ploughed in July, 1937, with a mouldboard plough and seeding was carried out, without any further cultivation, during the middle of May, using a combined cultivator-drill. Seed and superphosphate were sown at the rates of 45 lbs. and 100 lbs. per acre, respectively.

Lloyd Bros.' crop of "Nabawa" was on jam country which had been ploughed in August, 1937, with a mouldboard plough. It was cultivated with a springtyne implement before seeding, for which a combined cultivator-drill was used. Seed and superphosphate were applied at the rate of 60 lbs. and 90 lbs. per acre, respectively.

It is interesting to note that the crops of Mr. Hayes, Lloyd Bros. and V. Hamersley & Sons had been fed off in their early stages due to lack of green feed.

The diseases rust and take-all were in evidence and the former affected the varieties "Bena" and "Dundee" most noticeably, thus the planting of these varieties in rust-liable areas cannot be recommended.

THE BEVAN TROPHY.

Judge:—W. M. Nunn, B.Sc. (Agric.), Agricultural Adviser.

The 50 Acre crop competition for the trophy donated by Mr. A. W. Bevan for competition in the Wialki-Bonnie Rock area, was again conducted under the direction of the Wialki Branch of the Wheat Growers' Union.

Conditions governing this competition are the same as for the Royal Agricultural Society's Competitions.

The rainfall recorded at North Wialki is shown below:—

	Growing Period.												Total for
Station.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec	Year.
North Wialki	58	5	10	91	38	43	180	68	47	14	390	61	66	681

The Judge's awards and details of the treatment received by the winning crop are set out hereunder.

BEVAN CUP—WIALKI.

Competitor.	Address.	Variety.	Yield 1 point per bus.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Miguel, J. A.	Wialki	Bencubbin	9	9	9	14	13	54
Anderson, T.	Wialki	Bencubbin	7	9	9	14	12	51

Mr. J. A. Miguel's crop of "Bencubbin" was grown on salmon gum-mallee country which had been ploughed in early July, 1937, with a disc plough to a depth of 3 inches. It was springtyne cultivated in early September, 1937, and seeded during the middle of April, when seed and superphosphate were applied at the rate of 30 lbs. and 60 lbs. per acre, respectively.

FERTILISERS.

In accordance with the Fertilisers Act, 1928, the list of fertilisers registered in the present fertiliser year, which commenced on 1st November, 1938, is appended in tabular form.

As a guide to agriculturists in purchasing their manures, the unit values for the different forms of nitrogen, phosphoric acid and potash have been calculated from the retail prices per ton.

The main variations from last year's figures have been an increase of 1s. per unit for nitrogen in blood and bone, bonedust, etc., and for the same class of fertiliser the unit for phosphoric acid shows a rise of 3d. per unit. Ammoniacal nitrogen shows a decrease of 1d. per unit.

The prices of the other fertilisers have remained constant.

These unit values are shown in comparison with those of the previous three years, in the following table:—

UNIT VALUES.

	1935–36.	1936–37.	1937–38.	1938–39.
NITROGEN (N) as—	s. d.	s. d.	s. d.	s. d.
Dried Blood, Blood and Bone, Bonedust, and Bone and Flesh	22 0	21 8	23 0	24 0
Nitrate...	18 3	18 2	18 1	18 1
Ammonia	12 3	11 8	11 3	11 2
PHOSPHORIC ACID (P_2O_5) as—				
Water Soluble as Superphosphate ...	3 5	3 4	3 3	3 3
Citrate Soluble as Superphosphate ...	3 5	3 4	3 3	3 3
In Bonedust, Blood and Bone, and other Animal Fertilisers	5 9	5 6	5 9	6 0
Basic Phosphate	5 1	4 11	4 11	4 11
Acid Soluble in Superphosphate and Rock Phosphate	2 2	2 2	2 2	2 2
POTASH (K_2O) as—				
Sulphate	6 0	6 4	6 5	6 5
Muriate	5 0	5 6	5 7	5 7

FERTILISERS.

The following fertilisers have been registered at the Department of Agriculture under the Fertilisers Act, 1928, for the year commencing 1st November, 1938:—

Name of Fertiliser.	Reg. No.	Brand.	By Whom Registered.	Nitrogen (N) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on Rail at Works or Perth.
				Nitrate.	Ammonia.	Blood and Bone.	Bone-dust.	Water Sol.	Citrate Sol.	Acid Sol.	Total.	Sulphate.	Muriate.	
				%	%	%	%	%	%	%	%	%	%	
A.—MINERAL.														
1.—NITROGENOUS.														
(a)—Nitrogen as Nitrate.														
Nitrate of Soda	32	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	15·50	..	..	..	..	..	..	..	..	..	14 0 0
Do.	59	ML in diamond	do. do.	15·50	..	..	..	..	..	..	..	..	..	14 0 0
Do.	86	CSML	do. do.	15·50	..	..	..	..	..	..	..	..	..	14 0 0
Do.	130	Cresco	Cresco Fertilisers (W.A.), Ltd.	15·50	..	..	..	..	..	..	..	..	..	14 0 0
Do.	138	Champion	A. Hicks	16·00	..	..	..	..	..	..	..	..	..	..
(b)—Nitrogen as Ammonia.														
Sulphate of Ammonia	8	ICI	Cuming Smith & Mt. Lyell F.F., Ltd.	..	20·6	..	..	..	..	..	..	..	..	12 5 0
Do. do.	31	Sickle	do. do.	..	20·50	..	..	..	..	..	..	..	..	12 5 0
Do. do.	58	ML in diamond	do. do.	..	20·50	..	..	..	..	..	..	..	..	12 5 0
Do. do.	85	CSML	do. do.	..	20·50	..	..	..	..	..	..	..	..	12 5 0
Do. do.	125	Cresco	Cresco Fertilisers (W.A.), Ltd.	..	20·50	..	..	..	..	..	..	..	..	12 5 0
2.—PHOSPHATIC														
(a)—Rock Phosphate.														
Pacific Islands Phosphate	30	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	..	..	..	..	..	..	36·65	36·65	..	..	4 0 0
Do. do.	57	ML in diamond	do. do.	..	..	..	..	..	..	36·65	36·65	..	..	4 0 0
Do. do.	89	CSML	do. do.	..	..	..	..	..	..	36·65	36·65	..	..	4 0 0
Phosphate Powder	112	Cresco	Cresco Fertilisers (W.A.), Ltd.	..	..	..	..	..	..	36·65	36·65	..	..	4 0 0
(b)—Superphosphates.														
Florida Superphosphate (22%)	9	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	..	..	..	..	20·50	·50	1·00	22·00	..	..	3 12 6
Do. do. (23%)	10	do.	do. do.	..	..	..	..	21·25	·50	1·25	23·00	..	..	3 12 6
22% Superphosphate	36	ML in diamond	do. do.	..	..	..	..	20·50	·50	1·00	22·00	..	..	3 12 6
High Grade Super (23%)	37	do. do.	do. do.	..	..	..	..	21·25	·50	1·25	23·00	..	..	3 12 6
22% Superphosphate	63	CSML	do. do.	..	..	..	..	20·50	·50	1·00	22·00	..	..	3 12 6
High Grade Super (23%)	64	do.	do. do.	..	..	..	..	21·25	·50	1·25	23·00	..	..	3 12 6
"23" Super	111	Cresco	Cresco Fertilisers (W.A.), Ltd.	..	..	..	..	21·25	·50	1·25	23·00	..	..	3 12 6

(c)—Rock Phosphate and Superphosphate.														
Phosphate Mixture 50/50	29	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.					10·00	·50	18·50	29·00			4 1 6
Do. do.	56	ML in diamond	do. do.					10·00	·50	18·50	29·00			4 1 6
Do. do.	84	CSML	do. do.					10·00	·50	18·50	29·00			4 1 6
50/50 Phosphate	129	Cresco	Cresco Fertilisers (W.A.), Ltd.					10·00	·50	18·50	29·00			4 1 6
(d)- Basic Phosphate.														
Basic Phosphate	28	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.							17·00	17·00			4 4 0
Do.	55	ML in diamond	do. do.							17·00	17·00			4 4 0
Do.	75	CSML	do. do.							17·00	17·00			4 4 0
3.—POTASSIC.														
(a)—Potash as Sulphate.														
Sulphate of Potash	3	Palestine	Geo. Wills & Co., Ltd.									48·60		15 10 0
Do. do.	33	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.									48·60		15 10 0
Do. do.	60	ML in diamond	do. do.									48·60		15 10 0
Do. do.	87	CSML	do. do.									48·60		15 10 0
Do. do.	93	Sun	The Westralian Farmers, Ltd.									48·60		15 10 0
Do. do.	124	Cresco	Cresco Fertilisers (W.A.), Ltd.									48·60		15 10 0
(b)—Potash as Muriate.														
Muriate of Potash	2	Palestine	Geo. Wills & Co., Ltd.										50·00	14 10 0
Do. do.	34	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.										50·00	14 0 0
Do. do.	61	ML in diamond	do. do.										50·00	14 0 0
Do. do.	88	CSML	do. do.										50·00	14 0 0
Do. do.	97	Sun	The Westralian Farmers, Ltd.										50·00	14 10 0
Do. do.	131	Cresco	Cresco Fertilisers (W.A.), Ltd.										50·50	14 0 0
Kainit	94	Sun	The Westralian Farmers, Ltd.										14·00	*
Potash Manure Salts	96	do.	do. do.										30·00	*
4.—NITROGEN AND PHOSPHORIC ACID.														
Super and Ammonia, No. 1	21	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.		2·94			17·57	·43	·85	18·85			5 10 6
Do. do. No. 2	22	do.	do. do.		5·15			15·37	·37	·76	16·50			6 10 0
Do. do. No. 3	23	do.	do. do.		6·00			14·25	·40	1·10	15·75			6 15 0
Do. do. No. 4	24	do.	do. do.		6·87			13·66	·34	·66	14·66			7 4 0
Do. do. No. 5	25	do.	do. do.		10·30			10·25	·25	·50	11·00			8 14 0
Do. do. No. 1	48	ML in diamond	do. do.		2·94			17·57	·43	·85	18·85			5 10 6
Do. do. No. 2	49	do. do.	do. do.		5·15			15·37	·37	·76	16·50			6 10 0
Do. do. No. 3	50	do. do.	do. do.		6·00			14·25	·40	1·10	15·75			6 15 0
Do. do. No. 4	51	do. do.	do. do.		6·87			13·66	·34	·66	14·66			7 4 0
Do. do. No. 5	52	do. do.	do. do.		10·30			10·25	·25	·50	11·00			8 14 0

FERTILISERS.—*continued.*

Name of Fertiliser.	Reg. No.	Brand.	By Whom Registered.	Nitrogen (N) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on Rail at Works or Perth.
				Nitrate.	Ammonia.	Blood and Bone.	Bone-dust.	Water Sol.	Citrate Sol.	Acid Sol.	Total.	Sulphate.	Muriate.	
4.—NITROGEN AND PHOSPHORIC ACID.—*continued.*				%	%	%	%	%	%	%	%	%	%	£ s. d.
Super and Ammonia, No. 1	79	CSML	Cuming Smith & Mt. Lyell F.F., Ltd.	....	2·94	....	....	17·57	·43	·85	18·85	....	....	5 10 6
Do. do. No. 2	80	do.	do. do.	....	5·15	....	....	15·37	·37	·76	16·50	....	....	6 10 0
Do. do. No. 3	81	do.	do. do.	....	6·00	....	....	14·25	·40	1·10	15·75	....	....	6 15 0
Do. do. No. 4	82	do.	do. do.	....	6·87	....	....	13·66	·34	·66	14·66	....	....	7 4 0
Do. do. No. 5	83	do.	do. do.	....	10·30	....	....	10·25	·25	·50	11·00	....	....	8 14 0
Phosphate of Ammonia	106	Floraphos	J. A. Newman & Co.	....	15·60	....	....	31·20	....	....	31·20	....	....	35 0 0
Super and Ammonia, 1 : 1	119	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	10·30	....	....	10·25	·25	·50	11·00	....	....	8 14 0
Do. do. 2 : 1	120	do.	do. do.	....	6·87	....	....	13·66	·34	·66	14·66	....	....	7 4 0
Do. do. 3 : 1	121	do.	do. do.	....	5·15	....	....	15·37	·37	·76	16·50	....	....	6 10 0
Do. do. 6 : 1	122	do.	do. do.	....	2·94	....	....	17·57	·43	·85	18·85	....	....	5 10 6
5.—NITROGEN, PHOSPHORIC ACID AND POTASH.														
Potato Manure, "B"	11	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	....	3·75	....	....	14·50	·35	·75	15·60	4·50	....	7 2 0
Do. "C"	12	do.	do. do.	....	3·50	....	....	16·75	·40	1·10	18·25	....	....	5 16 0
Do. "E"	13	do.	do. do.	....	3·50	....	....	14·00	·30	·70	15·00	8·00	....	7 19 0
Do. "F"	14	do.	do. do.	....	6·00	....	....	14·25	·40	1·10	15·75	....	....	6 15 0
Do. "G"	15	do.	do. do.	....	3·50	....	....	10·50	·20	·60	11·30	16·00	....	10 0 0
Do. "H"	16	do.	do. do.	....	4·00	....	....	12·70	·30	·70	13·70	9·00	....	8 8 0
Do. No. 5	17	do.	do. do.	....	7·50	....	....	7·00	·20	·40	7·60	13·25	....	11 1 0
Orchard Manure	18	do.	do. do.	....	2·00	....	....	15·75	·40	1·10	17·25	....	5·00	6 6 0
Special Mixture, "K"	19	do.	do. do.	....	8·34	....	....	8·40	·20	·40	9·00	....	10·04	10 2 6
Do. "KP"	20	do.	do. do.	....	6·34	....	....	10·50	·20	·80	11·50	10·04	....	9 13 0
Tobacco Fertiliser	27	do.	do. do.	3·30		....	....	14·00	·50	1·00	15·50	5·70	....	7 10 0
Potato Manure, No. 2	38	ML in diamond	do. do.	....	3·50	....	....	16·75	·40	1·10	18·25	....	....	5 16 0
Do. No. 3	39	do.	do. do.	....	3·75	....	....	14·50	·35	·75	15·60	4·50	....	7 2 0
Do. No. 4	40	do.	do. do.	....	3·50	....	....	14·00	·30	·70	15·00	8·00	....	7 19 0
Do. No. 5	41	do.	do. do.	....	7·50	....	....	7·00	·20	·40	7·60	13·25	....	11 1 0
Do. No. 6	42	do.	do. do.	....	6·00	....	....	14·25	·40	1·10	15·75	....	....	6 15 0
Do. No. 7	43	do.	do. do.	....	3·50	....	....	10·50	·20	·60	11·30	16·00	....	10 0 0
Do. No. 8	44	do.	do. do.	....	4·00	....	....	12·70	·30	·70	13·70	9·00	....	8 8 0
Orchard Manure	45	do.	do. do.	....	2·00	....	....	15·75	·40	1·10	17·25	....	5·00	6 6 0
Special Mixture, "K"	46	do.	do. do.	....	8·34	....	....	8·40	·20	·40	9·00	....	10·04	10 2 6
Do. "KP"	47	do.	do. do.	....	6·34	....	....	10·50	·20	·80	11·50	10·04	....	9 13 0
Tobacco Fertiliser	54	do.	do. do.	3·30		....	....	14·00	·50	1·00	15·50	5·70	....	7 10 0
Potato Manure, "B"	65	CSML	do. do.	....	3·75	....	....	14·50	·35	·75	15·60	4·50	....	7 2 0
Do. "C"	66	do.	do. do.	....	3·50	....	....	16·75	·40	1·10	18·25	....	....	5 16 0
Do. "E"	67	do.	do. do.	....	3·50	....	....	14·00	·30	·70	15·00	8·00	....	7 19 0
Do. "F"	68	do.	do. do.	....	6·00	....	....	14·25	·40	1·10	15·75	....	....	6 15 0

Do. "G"	69	do.	do.	....	3·50	....	....	10·50	·20	·60	11·30	16·00	....	10	0	0
Do. "H"	70	do.	do.	....	4·00	....	..	12·70	·30	·70	13·70	9·00	....	8	8	0
Do. No. 5	71	do.	do.	....	7·50	....	....	7·00	·20	·40	7·60	13·25	....	11	1	0
Tobacco Fertiliser	73	do.	do.	3·30	....	....	....	14·00	·50	1·00	15·50	5·70	....	7	10	0
Do. do. No. 2	74	do.	do.	3·70	....	....	..	13·20	·30	·70	14·20	7·00	....	7	14	0
Orchard Manure	76	do.	do.	....	2·00	..	..	15·75	·40	1·10	17·25	....	5·00	6	6	0
Special Mixture, "K"	77	do.	do.	....	8·34	....	....	8·40	·20	·40	9·00	....	10·04	10	2	6
Do. "KP"	78	do.	do.	....	6·34	....	....	10·50	·20	·80	11·50	10·04	....	9	13	0
Potato Special	113	Cresco	Cresco Fertilisers (W.A.), Ltd.	..	4·00	..	....	12·70	·30	·70	13·70	9·00	....	8	8	0
Special Orchard Manure	114	do.	do.	....	8·34	....	....	8·40	·20	·40	9·00	....	10·04	10	2	6
Potato Manure	115	do.	do.	....	1·50	....	....	7·10	1·40	13·50	22·00	7·50	....	6	15	0
Orchard Manure	116	do.	do.	....	1·50	....	....	7·10	1·40	13·50	22·00	7·50	....	6	15	0
Mixed Manure	117	do.	do.	....	1·50	....	..	7·10	1·40	13·50	22·00	7·50	....	6	15	0
Vine Manure	118	do.	do.	....	1·50	....	....	7·10	1·40	13·50	22·00	7·50	....	6	15	0
†Special Lawn Manure	132	do.	do.	....	6·94	....	....	3·95	·23	5·67	9·85	6·02	....	12	0	0
Potato Manure	133	Eclipse	West Australian Meat Exports Coy., Ltd.	....	3·00	....	....	16·00	....	·25	16·25	4·25	....	7	10	0
6.—MISCELLANEOUS.																
Super and Manganese *	128	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	....	....	..	17·00	·50	1·00	18·50	....	....	7	10	0
B.—ORGANIC.																
(a)—Blood and Bone.																
Animal Fertiliser	1	State Abattoirs, Midland Junction	State Abattoirs, Midland Junction	....	....	8·00	....	....	....	5·00	5·00	....	....	10	0	0
Blood and Bone	6	Riverstone	Riverstone Meat Co.	....	....	5·50	....	....	5·00	9·25	14·25	..	....	7	5	0
Do.	35	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....	5·00	....	....	....	15·00	15·00	....	....	10	0	0
Do.	62	ML in diamond	do. do.	....	....	5·00	....	....	....	15·00	15·00	....	....	10	0	0
Do.	91	CSML	do. do.	....	..	5·00	....	....	....	15·00	15·00	....	....	10	10	0
Do. "G"	92	do.	do. do.	....	....	6·00	....	....	....	12·00	12·00	....	....	10	10	0
Do.	95	Sun	The Westralian Farmers, Ltd.	....	....	5·25	....	....	....	....	14·00	....	....	8	15	0
Do.	99	Wyndham	Wyndham Freezing, Canning & Meat Export Works	....	....	6·00	....	....	6·00	6·50	12·50	....	....	9	12	6
Do.	104	A.N.A. Surprise	C. A. Kirkby & Son	....	....	5·00	....	....	4·00	10·00	14·00	....	....	10	10	0
Do.	105	Apollo	Soap Distributors, Ltd.	....	....	7·00	....	....	....	....	14·00	....	....	10	7	6
Do.	127	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	....	5·25	....	....	....	14·00	14·00	....	....	10	10	0
Do.	109	A1 in circle	Haynes & Clements	....	....	5·25	....	....	3·00	9·00	12·00	....	....	11	5	0
Do.	110	Albany Freezing Works, Limited	Albany Freezing Works, Ltd.	....	..	6·00	....	....	....	....	12·00	....	....	9	10	0
Do.	135	Eclipse	West Australian Meat Exports Coy., Ltd.	..	....	6·00	....	....	....	....	12·00	....	....	10	0	0
Do.	137	"Robbs"	do. do.	....	....	5·25	....	....	....	....	14·00	....	....	9	15	0
Do.	139	Cockbills	Harrold & Murray	..	....	5·25	....	....	3·00	9·00	12·00	....	....	7	15	0
Do.	140	KBM	R. Bates	....	....	5·00	....	....	....	9·00	9·00	....	....	8	10	0
(b)—Bones.																
Bonedust	90	CSML	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....	....	3·50	....	....	22·00	22·00	....	....	11	0	0
Do.	126	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	....	....	3·50	....	....	22·00	22·00	....	....	11	0	0

† Contains traces of Magnesium, Iron, Copper, Zinc and Manganese as Sulphate.

* Contains 5·75% Manganese as (MnO_2).

FERTILISERS.—*continued.*

Name of Fertiliser.	Reg. No.	Brand.	By Whom Registered.	Nitrogen (N) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on Rail at Works or Perth.
				Nitrate.	Ammonia.	Blood and Bone.	Bonedust.	Water Sol.	Citrate Sol.	Acid Sol.	Total.	Sulphate.	Muriate.	
B.—ORGANIC.—*continued.*				%	%	%	%	%	%	%	%	%	%	£ s. d.
(*b*) *Bones*—continued.														
Bonedust	136	Eclipse	West Australian Meat Exports Coy., Ltd.	....	....	....	3·50	....	....	22·00	22·00	....	....	7 10 0
Do.	141	KBM	R. Bates	....	....	....	3·00	....	....	18·00	18·00	....	....	6 15 0
(*c*)—*Fish Fertiliser*	107	Cormo	M. F. Phillips	....	....	7·00	....	....	....	....	8·00	....	....	*
(*d*)—*Blood.*														
Dried Blood	5	Imperial	W. Angliss & Co. Pty., Ltd.	....	....	12·0 (as dried blood)	....	....	....	....	....	....	....	15 10 0
Do.	7	Riverstone	Riverstone Meat Co. Pty., Ltd.	....	....	13·0 (as dried blood)	....	....	....	....	....	....	....	13 10 0
C.—MINERAL AND ORGANIC.														
Manurial Insecticide	4	Kill-A-Mite	Kill-A-Mite Co.	....	....	....	2·02	....	....	....	3·76	....	2·51	*
Bone and Super	26	Sickle	Cuming Smith Mt. Lyell F.F., Ltd.	....	....	2·00		13·00	·80	4·70	18·50	....	....	6 17 6
Do.	53	ML in diamond	do. do.	....	....	2·00		13·00	·80	4·70	18·50	....	....	6 17 6
Do.	72	CSML	do. do.	....	....	2·00		13·00	·80	4·70	18·50	....	....	6 17 6
Fe tos	98	Floreat	T. S. McGill	....	9·38	....	....	15·00	·50	1·55	17·05	....	....	20 0 0
Domestic Garden, No. 1	100	Wondergrowth	W. J. Mathews	....	3·75		....	12·00	·30	3·20	15·50	....	....	*
†Special Mixture for Lawns	101	Sickle	Cuming Smith Mt. Lyell F.F., Ltd.	....	6·94		....	3·95	·23	5·67	9·85	6·02	....	12 0 0
† Do. do. do.	102	ML in diamond	do. do.	....	6·94		....	3·95	·23	5·67	9·85	6·02	....	12 0 0
† Do. do. do.	103	CSML	do. do.	....	6·94		....	3·95	·23	5·67	9·85	6·02	....	12 0 0
Bone, Super and Potash	123	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	....	....	1·00	....	....	14·00	14·00	1·00	....	4 17 6
Phosphoric Guano	108	Cormo	M. F. Phillips	....	....	....	2·2	....	....	....	23·89	....	....	5 2 6
B.S.P.	134	Eclipse	W.A. Meat Exports Coy. Ltd.	....	1·2‡	....	....	5·00	....	9·00	14·00	....	1·20	5 0 0

* Price on application. † Contains traces of Magnesium, Iron, Copper, Zinc and Manganese as Sulphate. ‡ Part Bonedust.

OAT, WHEAT, AND BARLEY VARIETY TRIALS IN THE DAIRYING DISTRICTS.

H. G. Elliott, Agrostologist.

Resumé of the results to date of these Trails conducted throughout the South-West Dairy Belt during the 1937 *and* 1938 *Seasons.*

These trials have been conducted for a number of years by officers of the Dairy Branch. During the season 1938 Atlas Barley was introduced for the first time and the wheat varieties deleted.

The objects of the trials are as follows:—

To determine which variety of oats, if any, gives higher yields of hay per acre than the variety "Algerian."

To determine if barley or wheat would give greater yields than the oat varieties.

Fertiliser:—In every case 1 bag (180 lbs.) of superphosphate was applied per acre.

Rate of Seeding:—2 bushels per acre for oats; 1⅓ bushels per acre for wheat and barley.

Method:—Each variety was sown in plots of half acre and in triplicate.

The following Table I. gives the results:—

	Algerian Oats.	Guyra Oats.	Mulga Oats.	Burts Early Oats.	Wongan Oats.	Nabawa Wheat.	Yandilla King Wheat.	Atlas Barley.
J. Johnson, Harvey—								
Tons, acre	2·45	2·49	....	2·45	2·47	1·60	1·77	....
% Yield	100	102	....	100	102	65	72	....
J. Rae, Yarloop—								
Tons, acre	0·86	1·07	0·92	0·86	0·80	1·31	1·10	....
% Yield	100	124	107	100	93	152	128	....
E. Lloyd, Denmark—								
Tons, acre	2·40	....	2·70	2·20	2·60	2·40	0·88	....
% Yield	100	....	113	92	108	100	37	..
R. J. Trigwell, Donnybrook—								
Tons, acre	2·33	2·28	1·46	1·42	0·97	1·22	1·26	....
% Yield	100	98	63	61	41	52	54	....
H. J. Blowfield, Harvey—								
Tons, acre	2·87	....	2·69	2·36	2·10	....	....	1·95
% Yield	100	....	94	82	73	....	....	68
J. A. Lynam, Bridgetown—								
Tons, acre	2·02	....	2·11	2·29	2·56	....	....	2·43
% Yield	100	....	104	113	127	....	....	120
Coley Bros., Vasse—								
Tons, acre	0·82	....	0·60	0·55	0·55	....	....	....
% Yield	100	....	73	66	66	....	....	....
J. Salarian, Waroona—								
Tons, acre	4·91	....	3·71	3·95	3·47	....	....	4·68
% Yield	100	....	76	80	71	....	....	95·3

(Hay Yields estimated.)

J. Johnson, Harvey.

Information supplied by A. M. Tindale, Dairy Instructor. The varieties were sown on 20-21st May, 1937, on well-drained red loam which was originally

timbered by redgum and jarrah. The land was disc ploughed and cultivated twice with the spading harrows prior to seeding. The rainfall during the growing period was 24 inches. The weights were taken on 26th October, 1937.

J. Rae, Yarloop.

A. M. Tindale, Dairy Instructor.

Plots were sown on 22nd and 23rd May, 1937, on grey sandy clay. The land was ploughed with a mouldboard plough and the seed harrowed in. The rainfall during the growing period was 24½ inches. The wheat in all plots showed better and stronger growth than the oats.

The soil dried out very early and was somewhat waterlogged during the winter months. The whole area was generally uneven and a poor stand.

The weights were taken on 17th and 18th November, 1937.

R. J. Trigwell, Donnybrook.

M. Cullity, Senior Agricultural Adviser.

Plots sown on a hillside with a northern aspect on a soil which varied from a greyish to brown clayey loam. Seeding was carried out on the 27th July on a well-worked seed bed.

The plots were cut as under: Nabawa, Burts Early, Mulga and Wongan on 12th November, 1937; and Guyra, Algerian, and Yandilla King on 29th November. Weighings were made from the stooks on the 24th November and 13th December.

H. J. Blowfield, Harvey.

G. Gauntlett, Agricultural Adviser.

Plots sown on red clayey loam on the 29th June, 1938. The rainfall during the growing period was 23½ inches.

The variey "Algerian" was the most outstanding but was much later in coming away than the others. "Mulga" made excellent growth during the winter months and is probably the best allround variety.

With the exception of "Algerian" all varieties of oats were attacked by leaf and stem rust, "Wongan" being most severely affected.

J. A. Lynam, Bridgetown.

A. M. Tindale, Dairy Instructor.

The seed was sown on red loam which was originally timbered with jarrah and redgum and which had been under subterranean clover for a number of years.

The land was ploughed on 19th May and harrowed twice. The seed and fertiliser were drilled in on 23rd May, 1938.

The rainfall during the growing period was 20½ inches.

All varieties came away well, "Wongan" varieties of oats and the barley being ahead of the others.

Coley Bros., Vasse.

J. M. Nelson, Dairy Supervisor.

The varieties were sown on a red sandy loam which was originally timbered with redgum, jarrah and a little blackbutt. The land was cropped the previous season with potatoes which were fertilised with 15 cwts. "B" potato manure per acre.

Excellent cultivation was carried out, the land being ploughed 4 inches, double disced, rolled, tyne harrowed and the seed and fertiliser drilled in with a disc drill on 30th and 31st May.

The results were very disappointing, due mainly to a root rot disease which was evident from the time the crop was 8 inches high.

J. Salarian, Waroona.

T. Lutz, Agricultural Adviser.

The trial was planted on 11th June on well worked seedbed with a disc drill, the soil being a dark chocolate loam which was originally timbered with redgum. The land was cropped to potatoes the previous season. The rainfall during the growing period was 22.8 inches.

The average yield for all varities is shown in the following Table 2.

Variety.	No. of Trials.	Hay. Tons/ac.	% Yield.
Oats—			
Algerian	8	2.33	100.0
Mulga	7	2.02	86.7
Burts Early	8	2.01	86.2
Guyra	3	1.95	83.7
Wongan	8	1.94	83.2
Wheat—			
Nabawa	4	1.63	70.0
Yandilla King	4	1.25	53.7
Barley—			
Atlas	3	3.02	129.6

These trials will be conducted again this season.

"THE JOURNAL OF AGRICULTURE"

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IRRIGATED PASTURE COMPETITION.

RESULTS OF SECOND YEAR'S INSPECTIONS—1938.

H. G. ELLIOTT, Agrostologist.

A. R. C. CLIFTON, Officer in Charge of Irrigation.

The above competition was inaugurated by the Harvey Agricultural Society in 1937, and a resumé of the results of the first year's inspections, 1937, was given in the March, 1938, issue of this Journal.

This competition embraces the whole of the irrigation areas extending from Waroona to Dardanup. The Agricultural Societies of Waroona, Harvey and Brunswick, together with the Waterloo P.P.A., also run individual annual competitions embracing the entries from their respective districts.

In the main competition the pastures are to be judged yearly for a period of three years, and the competitor gaining the highest total number of points for all inspections will be judged the winner.

Messrs. Cuming Smith & Mt. Lyell Farmers' Fertilisers, Ltd., have generously donated a trophy valued at 10 guineas for the winner at the conclusion of the competition. The Societies also award an annual prize for the winners in their area.

The results of the 1938 inspections, which were carried out during the months of June and December, have been combined and the results are given in the following table:—

TABLE I.

Competitor.	Drainage and Irrigation Layout and Condition.	Mixture.	Sward Uniformity.	Condition of Pasture according to age.	Management.	Total.
	20	20	20	20	20	100
J. Salarian, No. 2. Waroona	18	18	17½	17	16½	87
D. Moore (A. E. Jackson), Brunswick	16½	17½	16	13	14	77
C. E. Edwards, No. 1, Waterloo	16½	17½	13	13	16½	76½
J. Salarian, No. 1, Waroona	15½	16½	14½	15½	13½	75½
E. Holthouse, No. 2, Harvey	17	16½	16	11	12	72½
L. Temple, No. 2, Harvey	14½	16½	14	15	12	72
L. Temple, No. 1, Harvey	14½	16½	13½	15	12	71½
E. Holthouse, No. 1, Harvey	16½	17	14½	11½	12	71½
S. Bowers, Brunswick	16½	16	11½	11½	12½	68
C. E. Edwards, No. 2, Waterloo	16	15	11½	11½	13	67
C. F. Giblett, Harvey	15½	13½	13	10	12½	64½
W. C. Edwards, Burekup	14	12	10½	10	15	61½
H. Piggot, Brunswick	16	14	12½	7	10½	60
F. Reeves, Brunswick	15	12½	11	8½	11½	58½
T. P. Harris, Waterloo	13½	12	9½	10	12	57
L. & C. Hynes, No. 1, Waterloo	14½	12	10½	6½	11	54½
L. & C. Hynes, No. 2, Waterloo	14½	12	11	6½	10½	54½
T. Tyrell, Waterloo	13	10½	9½	9	11½	53½
J. J. Hynes, Waterloo	14	11½	10	6	8½	50

Note.—F. H. Beecher, Harvey and W. Noakes, Brunswick, both withdrew.

The winners of the annual prizes awarded by the Societies conducting the competition are as follow:—

Waroona Agricultural Society	..	J. Salarian's No. 2 entry.
Brunswick Agricultural Society	..	A. E. Jackson (D. Moore).
Harvey Agricultural Society	..	E. Holthouse's No. 2 entry.
Waterloo P.P.A.	..	C. E. Edwards' No. 3 entry.

Additional entries were received in the Waroona and Waterloo areas for the annual competition.

From the above table it will be seen that Mr. J. Salarian, Waroona, gained the highest for the two inspections during the second year. The pasture exhibited consisted of White Clover, Perennial Ryegrass and Cocksfoot as the dominant species. Subterranean Clover, Lotus Major and Yorkshire Fog were present as minor constituents, and couch grass occurred in small isolated patches.

This field has been rotationally grazed throughout, the intervals between grazing varying from 14 to 24 days according to the season and growth recovery of the pasture species. The method of grazing which is being practised by this farmer is highly commended, but it is suggested that the periods between grazing of this type of pasture should not be less than 18-21 days. Some authorities are of the opinion that even a longer period between grazing would be advantageous, but until further information on this subject, under existing conditions, is obtained, present indications show that approximately 21 days is giving the most economical results from a grazing point of view.

The renovation carried out on the winning pasture during June of last year was severe, but resulted soon after in phenomenal vigour and production of the pasture. With the exception of one or two small patches of dodder, practically no weeds could be found over the area. It is considered that, with an efficient system of winter renovation, dodder can be eventually controlled.

Table II. gives the results of the four inspections, 1937 and 1938.

Table II.

Competitor.	1st Inspn. 1937.	2nd Inspn. 1937.	3rd Inspn. 1938.	4th Inspn. 1938.	Total.
J. Salarian, No. 2	70	71	87	87	315
C. E. Edwards, No. 1	78	82	79	74	313
D. Moore (A. E. Jackson) ..	64	73½	78	76	291½
E. Holthouse, No. 2	69½	75	72	73	289½
J. Salarian, No. 1	69	60	72	79	280
L. Temple, No. 1	73½	62	76	67	278½
L. Temple, No. 2	73	61	76	68	278
C. E. Edwards, No. 2	64	76	71	63	274
E. Holthouse, No. 1	71	50	68	75	264
S. Bowers	60	59	68	68	255
T. P. Harris	55	77½	54	60	246½
F. Reeves	63	61	58	59	241
C. F. Giblett	57	47½	64	65	233½
H. Piggot	49½	56½	53	67	226
W. C. Edwards	47	51½	58	66	223½
T. Tyrell	55	51½	59	48	213½
L. & C. Hynes, No. 2	59½	50½	50	59	209
L. & C. Hynes, No. 1	53	45	50	59	207
J. Hynes	50½	45½	50	50	196

This table shows that Mr. Salarian's No. 2 entry is now leading by two points from that of Mr. C. E. Edwards' No. 1 entry. At the time of the last inspection, 1938, Mr. Edwards' entry was showing a considerable amount of scalding, due to insufficiency of attention during the watering operations. The pasture consists of Perennial Ryegrass and White Clover, with an excellent ground cover. The

sward was very even, this being due to the area being cut for hay some three weeks prior to inspection.

The results of the second year's inspections showed that:—

Generally, the management of the irrigated pastures has been neglected, more particularly with reference to grazing, this being due, to a great extent, to the phenomenal growth of annual pastures which occurred during the spring months. Many of the competitors had left their irrigated pastures for hay and consequently, when the first application of water should have been given, hay was still on the ground. This meant a considerable opening up of the sward by the killing off of a number of the perennial species, particularly the White Clover. If a farmer intends to cope with the prolific spring growth of his annual pastures by grazing, the irrigated fields should not be left for hay cutting, but should be cut early for silage. This operation would overcome the opening up of the pasture, prevent the entry of weeds and assist in checking the couch grass spread—all of which, if allowed, increase at the expense of the more valuable perennial pastures species.

The layouts generally were unaltered since the previous inspections, with the exception of the head ditches. In the majority of cases at the second inspection, 1938, they were foul with weeds and unfit to be used, although attempts had been made to water some of the competition pastures without first reconditioning the ditches since the last irrigation season. This condition meant further points lost in the management section, owing to scalding, apparently due to the condition of the head ditches being such that a full head of water could not be used or properly controlled.

Fertilisers:—Suitable fertiliser for pastures is required not only to produce a high yield of green material, but to ensure it having a maximum feeding value. Phosphate is the manurial constituent mainly required. The fertiliser rates per acre used by the competitors varied from 3-7 cwts. per annum, applied in 2 to 4 applications. Superphosphate is the principal fertiliser applied, but in odd instances small quantities of sulphate of ammonia and potassic fertilisers have been used.

Weeds:—The main weeds encountered were the various types of rushes, particularly in the Brunswick-Waterloo area. It is unfortunate that many irrigated pasture fields are infested with these rushes, and also that this infestation has extended during the last few seasons. Rushes are, generally speaking, moisture and acid loving weeds, which do not thrive on well drained and properly managed pastures. The most efficient method of control is to drain the land efficiently where required, cut the rushes close in April followed by efficient topdressing with superphosphate; in November and the following April cut and fertilise again. It is essential that cutting should not be later than November to prevent seed formation. The pest is rapidly spread by means of seed. Couch grass is also a problem on many areas. If the pasture is heavily grazed, fertilised and efficiently renovated in May, much will be accomplished to stimulate the White Clover and suppress the couch grass spread.

Renovation:—Although surface harrowing to spread animal droppings was carried out in most instances, it was generally insufficient as uneven swards and a considerable amount of wastage were observed during the last inspection. Many competitors are topping their pastures, and having once carried out this practice will continue to do so, as the benefits are most marked.

Drainage:—It must be remembered that it is more or less futile to attempt to improve irrigated pasture by manuring if the soil is in need of drainage, and unfortunately many of the irrigated pastures judged were in need of more ade-

quate drainage. Drainage is essential for permanent pasture production. Waterlogged soils generally produce pastures of poor quality—moreover it is almost impossible to suppress the growth of rushes if the pastures are winter waterlogged.

Even though a thorough system of drainage may not be possible, much improvement can be effected by the cleaning out of existing drains and by keeping drain outfalls clear, so that the drainage water is allowed to run away freely.

Uneven Swards:—In many pastures the ryegrass has developed perched crowns, this being due to two main factors:—

(1) Lack of efficient surface drainage.

(2) Insufficiency of soil consolidation prior to seeding.

These perched crowns are liable to severe damage during grazing and the plants are rendered liable to heat and wind damage during the summer months particularly when heavy grazing occurs.

Only good watering methods associated with good layout and adequate drainage, renovation and liberal fertilising, will ensure a persistently high production and an attractive appearance of an irrigated pasture.

LAMB MARKING.

CARE AND CLEANLINESS ESSENTIAL.

By HUGH MCCALLUM,
Sheep and Wool Inspector.

Although lamb marking is a routine which the farmer has carried out year after year, and that the procedure is generally recognised as having an important bearing on the health and early development of the lamb, there still appears to be a casualness on the part of some farmers while this phase of the management is being carried out. It is of paramount importance in the nurturing of lambs to see that all the conditions favouring an early start are supplied, so that the lambs' propensities towards growth rate, growth of quality wool and other breed characteristics may obtain maximum expression.

One of these conditions, of course, is a method of marking that will minimise shock, bleeding, infection, bruising and mismothering, all of which cause a set-back to the lamb. To do this the marking is best carried out on a cool, dry morning and the lambs should be rested. The operation is extremely trying to the lambs in cold, wet weather, numbers often dying. The question of age is usually left to the discretion of the farmer and varies from three to five weeks.

Cleanliness, that is in the bacteriological sense, is essential to prevent the wounds becoming septic and the contraction of tetanus (lock-jaw). As a preventive measure a disinfectant should be spread on the ground and points of contact such as rails, etc., and the earmarkers and knives kept in a disinfectant immediately before and between operations. The order of the operation is—1, ear-marking; 2, castrating; 3, tail-docking.

The catcher should be quick but gentle in catching and handling the lambs. He should hold the legs firmly, but not too tightly and let the rump of the lamb rest on the yard rail with its back resting on his chest. On no account should the legs be pulled too far apart, as it often injures the limbs.

After ear-marking, the operator takes the tip of the scrotum between his first finger and thumb of the left hand and using the knife in his right, cuts off

about half an inch of the tip, sufficient to allow the testes to be gently squeezed out with the fingers and thumb and grasped by the teeth. They should be drawn out together as gently as possible without biting or breaking them. With practice the work becomes easy and can be done very rapidly. If a testicle does not come down, do not waste time bruising the organs, but leave that lamb undocked, so that it may readily be recognised later, when the operation can be completed or the lamb killed.

The quarters and cuts should be swabbed with a suitable disinfectant, care being taken to prevent its entry into the purse, as it delays healing.

Although the tailing process is simple, many unsightly tails are still prevalent on some farms. The second joint of the tail vertebrae is found by pressing with the thumb and forefinger of the left hand, the skin being pushed over it towards the rump so that when a clean incision is made through the joint, the end of the bone is not protruding, but covered by the skin that slips back over it. After swabbing the tail, the lamb should be released so that it drops on all four feet, not on its rump, as this may cause immediate contamination of the wounds and is a strain on the limbs.

After marking is completed, the flock should be kept well in hand to see that all the lambs are mothered. One advantage of marking in the morning is that the lambs have the rest of the day to find their mothers, whereas if they were left until night they may not find their mothers and severe losses might be incurred, especially if the night is cold and damp. The lambing percentage may be ascertained by counting the tails.

THE BLOWFLY MENACE.

By Hugh McCallum,
Sheep and Wool Inspector.

Every sheep farmer is undoubtedly aware of the enormous economic losses due to the ravages of the blowfly. Under many farm conditions some losses cannot be avoided, but in most cases these are far too large, and it should be the object of every farmer to minimise these as far as is possible. It appears that mortalities have been on the increase owing to the greater wool production of sheep and the consequent increase in yolk and foreign matter in the wool, thus offering an added attraction for the fly. If the above is so, our methods of dealing with this pest must correspondingly increase in efficiency.

SIGNS OF STRIKE.

It is an easy matter to tell when sheep are struck by just standing off and watching them for a short time. Here and there they will be seen rubbing themselves in the same way as they do for lice; stamping, trying to reach their hindquarters with their mouths; and in the case of rams struck on the belly, trying to scratch themselves with their hooves. In many cases the maggots may not be visible, but on parting the wool they will easily be seen, and on clipping the wool a raw patch may be revealed where the maggots have broken the skin.

PREVENTION OF STRIKE.

Rigid sanitation will greatly facilitate the eradication of the blowfly and it is imperative that the farmer should attend to all necessary details. The carcases of dead animals and the entrails, etc., of slaughtered sheep should be disposed of,

preferably by burning, but if this is not practicable, by burying deeply. The skins should be stretched out to dry in the desired manner as sweating skins bundled together afford a good breeding ground. Blowfly traps are useful if placed where flies accumulate, *e.g.* the killing shed. Rams should be inspected before mating with the ewes, as if struck they may convey the maggots to the latter when serving.

It is generally recognised that plain bodied sheep are much less susceptible to attack than wrinkled ones; it is of advantage, therefore, to cull all badly wrinkled sheep, particularly those with wrinkles around the tail, down the thighs and over the rump.

Crutching is an essential operation and very useful in lowering the percentage of "strike," and should be carried out at definite periods according to the particular conditions of the farm. Crutching removes stained and daggy wool from the breech which is attractive to the fly; usually a repellent is rubbed over this area after crutching.

Mules' Operation.—This consists of removing the folds of skin which are an inducement for "strike." The operation can be carried out on lambs as early as three weeks old and on the healing of the skin the animal appears plain bodied. This, however, must be recognised as only a temporary measure of control as these apparently plain-bodied sheep may throw wrinkly progeny which will require treatment. Culling, therefore, as mentioned previously, is a good practice.

Dipping at the correct time also has a beneficial influence in preventing attack as the wool retains some of the dip.

Jetting.—This method is carried out by spraying the wool with a fly repellent through fine nozzles. Experimental work in the Eastern States shows that this control measure gives satisfactory results. A suitable solution is one containing Calcium Arsenite.

There are many useful preparations sold by stock firms with directions for applying. One suitable preparation is composed of glycerine and boric acid in the proportions of 1 gallon of glycerine to 3 lbs. of powdered boric acid, which, when stirred and heated, forms various borates of glycerine which can be kept in stoppered bottles ready for use. This kills the maggots, induces the healing of the skin, and is an excellent measure to prevent "re-strike."

AN INVESTIGATION OF THE WASTAGE IN EXPORT LAMBS DUE TO DELAYED SLAUGHTER.

F. L. Shier,
Export Lamb Adviser.

A question of considerable importance to the lamb industry, particularly in view of the large extent of the lamb-raising belt in this State, and the distances of many of the producing areas from the export treatment works, is the wastage of lambs due to the time in transit from the farm to the meat works.

Some information is available* which indicates that there is a live weight loss of approximately 5 lbs. between the farm weight when the lambs are removed from their mothers, and the pre-slaughter weight at the works after an interval of 24 to 30 hours. There is, however, no experimental data regarding carcase loss, or the effect on carcase quality as a result of the time lag between the farm and the

*Lambs for Export—Sutton, Thomas, Davenport, Jnl. Dept. Agric., W.A., Vol. 11: 355, 1934.

works. Amongst the farmers it has been frequently stated that the carcase loss is in the order of 2-3 lbs. in the first day. This impression has probably been gained from the fact that the carcase weight is approximately half that of the live weight, and the live weight loss in the first 24 hours is about 5 lbs.

It is possible, however, that all or most of this early live weight loss may simply be due to the voiding of excreta and the actual carcase losses very small indeed. An experiment designed to obtain data on this question was carried out during the 1938 season with lambs from the Avondale Research Station. This experiment is described and discussed in the present paper.

DETAILS OF THE EXPERIMENT.

From the main flock of lambs (Border Leicester-Merino x Southdown) an even line of 120, about 50 lbs. live weight, were ear-tagged on 21/7/38. On 22/8/38 the 120 lambs were weighed and four even groups, each of 20, were random selected. Each group was wool branded with an appropriate mark for ease of drafting at the export treatment works. The 80 lambs were then transported to the Robb's Jetty works by motor truck. The work of mustering, weighing, grouping and transport on 22/8/38 was carried out as quickly as possible, the first group being slaughtered 8 hours after mustering commenced. Group 2 was slaughtered 32 hours after mustering; Group 3, 56 hours; and Group 4, 77 hours. The lambs received no feed or water after leaving the paddock at the farm. The following details were obtained—individual, farm weights, pre-slaughter and carcase weights and grade. The carcases were forwarded to London and a report was furnished by the Head Salesman of Messrs. Sheed, Thomson & Co., Ltd., on the quality of each group.

Results—

The mean figures of each weighing, together with the range, are given in lbs. in Table 1 hereunder:—

Table 1.

Group.	Hours after Mustering Slaughtered.	Weight at Avondale.	Pre-slaughter Weight.	Loss from Avondale to Pre-slaughter.	Carcase Weight.		Loss from Farm to Hooks percent.	
					Robb's Jetty.	London.	Robb's Jetty.	London.
1	8	67·4	64·7	2·7	32·6	32·7	51·6	51·5
Range	...	(63–72)	(60–69)	...	(30–36)	...	...	...
2	32	66·7	61·5	5·2	31·9	32·2	52·2	51·7
Range	...	(63–71)	(56–65)	...	(29–35)	...	...	...
3	56	67·2	60·8	6·4	31·5	31·8	53·1	52·7
Range	...	(63–72)	(57–64)	...	(29–35)	...	...	...
4	77	67·3	58·2	9·1	31·0	31·1	53·9	53·8
Range	...	(63–72)	(54–62)	...	(29–35)	...	...	...

The London weights are included as well as those from Robbs Jetty, as it is felt that the average of these two would level out any slight inaccuracies of weighing, and also at the abattoirs the lambs are weighed "hot" immediately after dressing, but with the scales adjusted to deduct an allowance of 4 per cent. The London weight is, of course, the weight of the cold carcase. It is obvious from these two sets of figures that the London weight is similar to the abattoirs weight where the automatic deduction is made.

Grading—

A summary of the grading is given in Table 2 (number of carcases) :—

Table 2.

Group.	Firsts.	Seconds.	Thirds.
1	18	2	...
2	15	3*	2
3	16	4	...
4	13	5†	2

1 carcase graded 2nd on account of colour.

†3 carcases graded 2nd on account of colour.

London Report—

The relevant sections of the report of the Head Salesman read as follows:—

Taking each group as a whole, there was practically no difference as regards wastage—there was not any waste fat on the back of the loin, nor did they have wastefully fat kidney knobs, or wastefully fat shoulders; in fact, some in each 20 lot were rather thin for First Quality lambs (Blue Gum).

As regards bloom—there was no difference whatever in each group in colour or bloom.

Sappiness.—Again, there was no difference as regards sappiness, or what we (in Smithfield) should term "colour in bone"—*i.e.* blue-boned; they were all blue-boned lambs.

Discussion—

An examination of Table 1 shows that there is an average loss in live weight of approximately 2¾ lbs. in the first eight hours after the lambs are removed from their mothers, increasing up to 9 lbs. after 77 hours. It is quite apparent, however, that this loss is largely excreta, as the average carcase weight of Group 4, killed 69 hours after Group 1, was only 1.6 lbs. lighter than that of the latter. The average carcase weights, as shown in columns 5 and 6, would appear to indicate that there is an average loss in carcase weight of approximately ½ lb. per day when slaughter is delayed up to three days. However, when the individual figures are examined statistically, even in the extreme case of Groups 1 and 4, the average differences are not significant.

Grading and Quality—

The grading returns do not show any significant difference between the groups, although three carcases in Group 4 and one in Group 2 were graded down to second-grade owing to colour. It is not possible to say whether this condition has been brought about by the long period of starvation. The London report is somewhat sketchy, but indicates that the delayed slaughter had no detrimental effect on the bloom and sappiness of the carcases.

Summary—

An experiment is described in which 80 Border Leicester-Merino x Southdown sucker lambs were divided in four groups and killed at 8, 32, 56 and 77 hours after removal from their mothers.

The average loss in live weight rose from 2¾ lbs. at 8 hours to 9 lbs. after 77 hours, but it was evident that this loss was largely excreta, since there were no significant differences in carcase weight or quality between the groups. There was, however, an apparent average daily loss of approximately half a pound. Further work on this aspect is proposed for the coming season.

Acknowledgment is made to the Manager (Mr. W. L. Morgan) of the W.A. Meat Export Co., Robbs Jetty, for permission to obtain the individual details and to the assistance rendered by the officers of the company.

PASTURE DEVELOPMENT.

THIRD YEAR'S RESULTS OF SPECIES TRIALS UNDER CONTROLLED METHODS OF GRAZING IN IRRIGATED AREAS.

H. G. Elliott, Agrostologist.

During the last four years the Australian Dairy Council has made available funds for the conduction of a number of experiments designed to increase and improve pasture production in Western Australia. The Dairy Council has now been merged with the Australian Dairy Board, which body has continued the work previously started and has made increased funds available for further investigations. The experimental work is controlled by a West Australian Pasture Improvement Committee working in close co-operation with the Department of Agriculture.

The following article gives a resumé of information which has been obtained from two experiments at Hamel and Waroona.

C. H. Henning, Hamel.

The information with reference to soil, cultivation, method of seeding, etc., which were carried out on this area is given in the March 1937 issue of this Journal.

The objects of the experiment are—

1. To determine the most suitable grass species in association with white clover for the establishment of permanent pasture under irrigated conditions on the soil type selected in this irrigation area.
2. The collection of information regarding the carrying capacity of these pastures on small irrigated areas.
3. To determine the yields per acre of green material from the various mixtures under existing conditions.

The total area now under pasture has been increased from 8.25 to 10.05 acres, a full year's grazing having been obtained from the new area—Field No. 5.

Irrigation.

During the past season four waterings were given, the dates being 7th January, 11th February, 1st and 25th December.

Fertiliser.

Three applications were given during the season, the first on 2nd February at the rate of 212 lbs., superphosphate per acre, the second on 12th September at 112 lbs., and the third on 14th November also at the rate of 112 lbs. per acre, making a total of 448 lbs. superphosphate per acre for the year. During the first year 4 cwts. per acre were applied in two applications and in the second year 4½ cwts. per acre also in two applications.

The result of the First and Second Year's operations were published in the March, 1937, and 1938, issues of this *Journal*.

Cultivation.

On 27th July the whole area was completely renovated with a rotary prong type of renovator followed by a zig-zag and chain harrow combination. A thorough aeration combined with the breaking up of the cattle droppings was obtained.

On 19th August the irrigation furrows were cleaned out with a "Sunbuster" plough which had been modified slightly. The spoil from the plough was broken down efficiently with a disc cultivator and T-bar roller.

On 25th July rushes which were accumulating mainly in the irrigation furrows were slashed, and on 10th November the majority of them were grubbed out, and at the present time the whole area is free from this pest.

Drainage.

This was improved considerably during the season and at no time were the plots too wet for grazing.

Seed Mixtures.

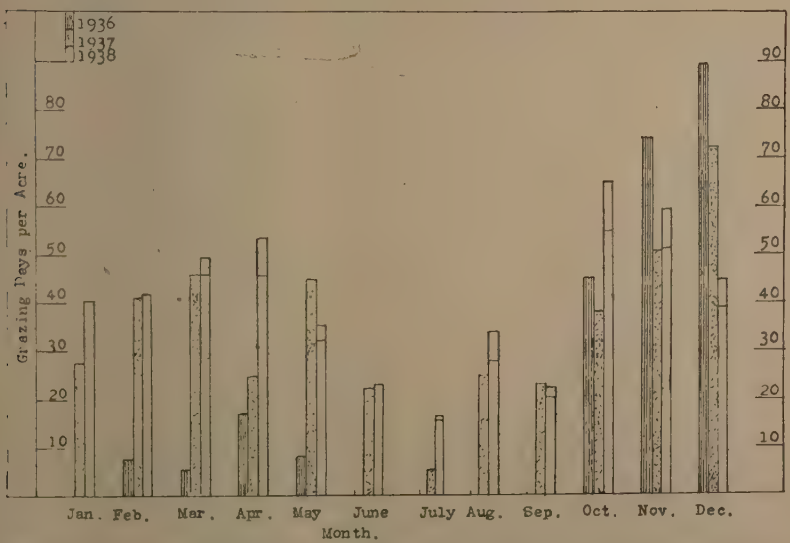
The seed mixtures sown were as follow. In each case certified New Zealand white clover at the rate of 2 lbs. per acre was incorporated:—

Field No. 1.	N.Z. certified mother strain perennial rye grass	8 lbs. per acre.
Field No. 2.	N.Z. certified akaroa cocksfoot	10 lbs. per acre.
Field No. 3.	Certified Phalaris tuberosa	4 lbs. per acre.
Field No. 4.	N.Z. tall fescue	8 lbs. per acre.
Field No. 5.	Paspalum	4 lbs. per acre.

Grazing.

The following Graph No. 1 shows the "Grazing Days per Acre" obtained per month from each field for the past three years.

Graph 1.—Cow Grazing Days per acre.



Graph showing Grazing Days (8 hours) per acre. Note lower line on 1938 column gives grazing days per acre obtained for all fields 1 to 5.

Carrying capacity—8.25 acres 1936 = 1 cow to 1.46 acres.
8.25 acres 1937 = 1 cow to 0.84 acres.
8.25 acres 1938 = 1 cow to 0.73 acres.
10.05 acres 1938 = 1 cow to 0.83 acres.

Total Grazing 1938—

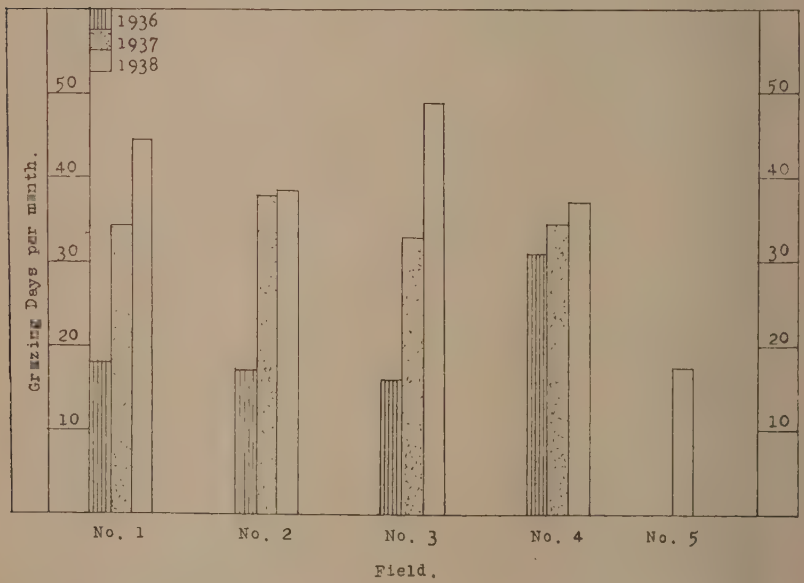
32,957 grazing hours from 8.25 acres = 3,990 grazing hours per acre
= 499 grazing days per acre.
35,430 grazing hours from 10.05 acres = 3,522 grazing hours per acre
= 440 grazing days per acre.

From the above graph it will be seen that the grazing obtained for the winter months has shown a decided improvement over that of the last two seasons. As was the case for the previous year, July was the month when the least amount of grazing was obtained, being 17.1 grazing days per month against 5.0 for the previous year.

The following Graph No. 2 shows the "Average Grazing Days per Month" for the twelve months of each year 1936, 1937, and 1938 for the various grass species in association with white clover:—

Graph 2.

Cow Grazing Days (8 hours) per acre.



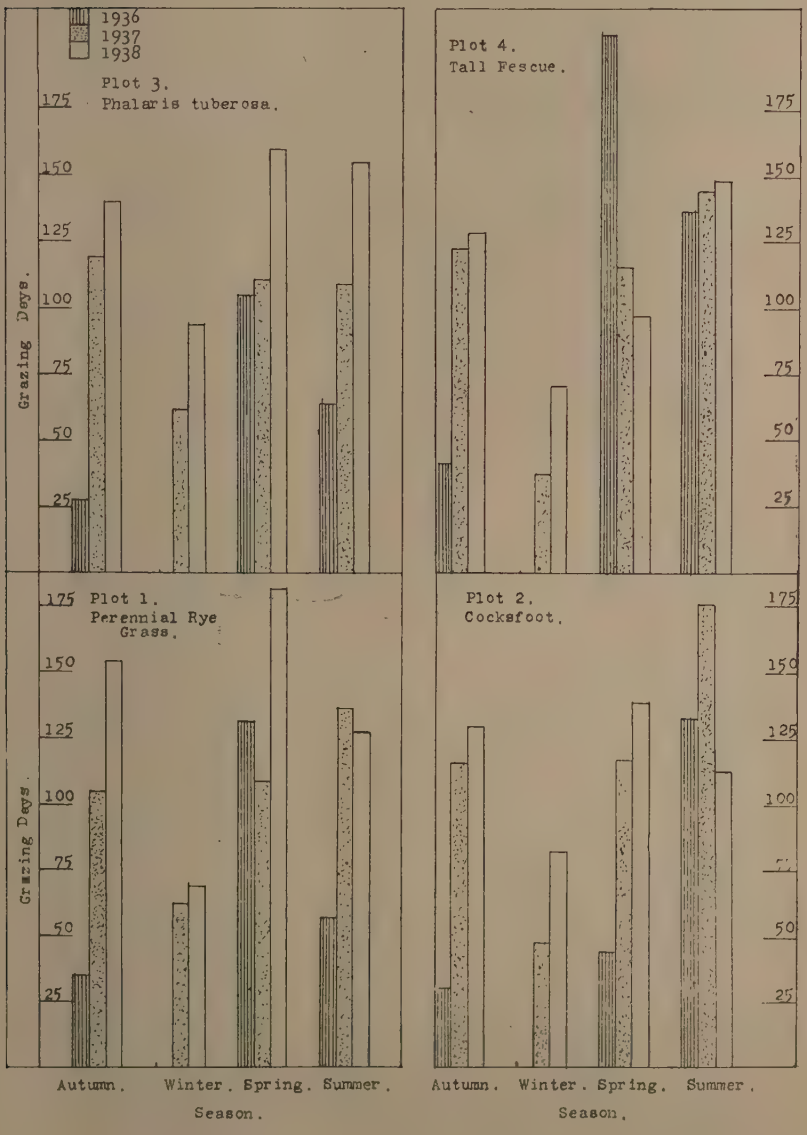
The average grazing days per month for Fields Nos. 1 to 4 for the year 1938 was 41.6, which is an increase from 35.0 grazing days per month for 1937. Field No. 5 only came into production in 1938.

It will be noted that fields Nos. 1 and 3 are still giving a steady increase in grazing days, while field No. 4 has only given a slight increase. No noticeable improvement was obtained in field No. 2 which gave the highest number of grazing days during 1937. Field No. 5 shows approximately the same production as did fields Nos. 1, 2, and 3 on their first season 1936.

The following series of graphs in Graph No. 3 show the "Quarterly Seasonal Grazing" figures for each field for the three years:—

Graph 3.

Three-Monthly Seasonal Grazing Days for the Four Fields.



An examination of these graphs will show that the autumn production of all fields has increased steadily, the best production being obtained from field No. 1—perennial rye grass, this being followed by field No. 3—Phalaris tuberosa. It is very pleasing to see the steady increase of grazing which has been obtained from all fields during the winter months, the greatest increases during 1938 being obtained from fields Nos. 2, 3, and 4.

The average spring production also has shown a decided increase. All fields, with the exception of No. 4—tall fescue, have given increased grazing. No. 4, however, has shown a decline.

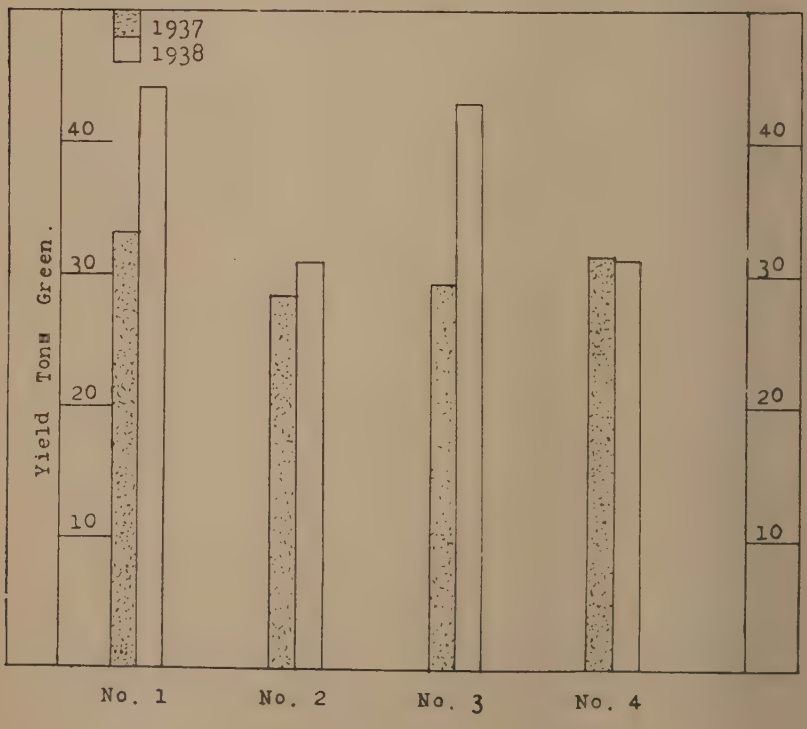
The summer production average was slightly less for 1938 than 1937, the biggest decline taking place with field No. 2 cocksfoot, with a small decline in field No. 1—perennial rye grass. Field No. 3—Phalaris tuberosa gave a decided increase over that of the previous seasons.

Yields of Green Material per Acre.

The following graph No. 4 gives the yields of green material which were obtained from each field for the two years 1937 and 1938:—

Graph 4.

Annual Production in Tons for the Four Fields.



It will be seen from the above graph No. 4 that, although a very high average yield (30.5 tons) per acre was obtained during 1937, this was exceeded in 1938, the average being 37.3 tons. Fields Nos. 1 and 3 gave very much higher yields and showed a considerable increase on that of the previous season. This increase also is reflected in graph No. 2 with the average grazing days per month obtained from these two fields.

The production in tons of green material from the four fields for the periods August to December for the three years is given in the following table No. 1.

Table No. 1.

	1936.	1937.	1938.
	Tons.	Tons.	Tons.
Field No. 1	12.7	17.7	23.9
„ No. 2	11.1	14.1	17.9
„ No. 3	10.6	15.2	22.9
„ No. 4	8.1	15.8	15.8

A decided increase is being obtained for the above period on all fields with the exception of No. 4 (tall fescue).

The following table No. 2 gives the average "Three-Monthly Yields per Acre" of all plots for the four seasons of the year:—

Table No. 2.

Season.	1937.	1938.
Autumn	5.3	8.4
Winter	1.3	3.2
Spring	12.6	10.9
Summer	11.3	14.7

Comparing the figures it will be seen that a decided increase in the winter yield has taken place and that the autumn and summer production also has shown a good increase. A decrease, however, has occurred in the spring production, which is not of serious moment.

Graph No. 5 (on the following page) gives the "Three-Monthly Yields per Acre" for the four fields for two years.

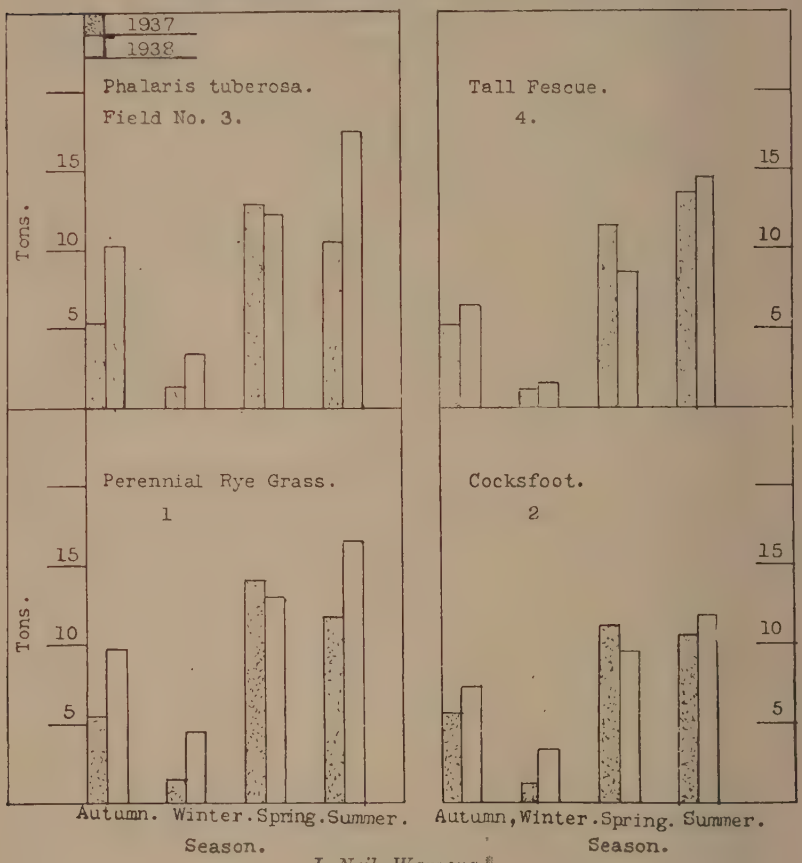
The autumn production for fields Nos. 1 to 3 has shown a decided increase over that of the previous seasons. The greatest increase in winter yield was obtained from field No. 1. Field No. 4—tall fescue only showed a slight increase in winter production. In regard to the spring production, the biggest decrease took place on field No. 4 followed by field No. 2. The other two fields only showed a slight decrease.

Fields Nos. 1 and 3 gave the greatest increases in yield for the summer production, while fields Nos. 2 and 4 only showed a slight increase over that of the previous season.

While the observations will not be completed for a further two seasons, some tentative conclusions which appear legitimate are given at the end of this article.

Graph 5.

Three-Monthly Seasonal Yields for the Four Fields.



*J. Neil, Waroona.**

The objects of the experiment are the same as those given above for Mr. C. H. Henning, Hamel.

An area of 12.94 acres was selected, divided into five fields, the area of the fields being as follows:—Fields Nos. 1, 2, 4, and 5—2.39 acres each; field No. 3—2.5 acres.

Seed Mixtures.

The seed mixtures sown were as follow. In each case certified white clover at the rate of 2 lbs. per acre was incorporated.

Field No. 1—N.Z. Certified Mother Strain Perennial Rye Grass	8 lbs. per acre
Field No. 2—New South Wales Paspalum dilatatum ..	10 lbs. ,,
Field No. 3—N.Z. Certified Perennial Rye Grass ..	4 lbs. ,,
Paspalum	8 lbs. ,,
Field No. 4—N.Z. Tall Fescue	8 lbs. ,,
Field No. 5—Certified Phalaris tuberosa	4 lbs. ,,

* All particulars with reference to soil, cultivation, sowing, etc., have been supplied in the March, 1937, issue of this *Journal*.

Fertiliser.

A total of 6 cwts. superphosphate per acre was applied in three applications of 2 cwts. each in February, May, and September, 1938. Four applications totalling 720 lbs. per acre were applied in 1937, and 900 lbs. superphosphate plus 100 lbs. sulphate of ammonia was given during 1936.

Irrigation.

The fields were irrigated five times during the year, viz., 12th January, 7th February, 28th February, 28th November, and 25th December, 1938.

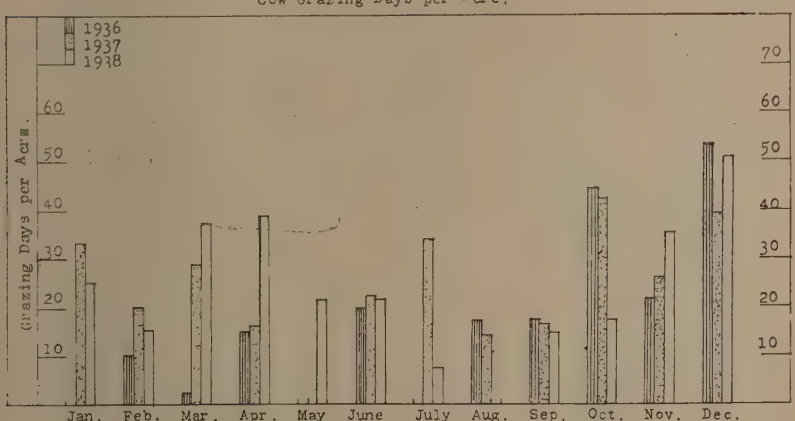
Cultivation.

On 9th May the whole area was harrowed with a knife blade pasture type of harrows. On 25th July all fields were severely renovated with a rotary prong type of renovator double-lapped, followed by the pasture harrows. A very rapid growth response was noticed after this operation. On 30th September all the irrigation furrows were cleaned out with the altered "Sunbuster" plough.

Grazing.

Graph No. 6 gives the "grazing days" which were obtained per month from each field for the years 1936, 1937, and 1938:—

Graph 6.



Carrying capacity of whole area—

1936	1 cow to 1.80 acres
1937	1 cow to 1.24 acres
1938	1 cow to 1.28 acres

Total grazing, 1938—

29,890.6 grazing hours from 12.94 acres.
2,286.6 grazing hours per acre.
285.8 grazing days per acre.

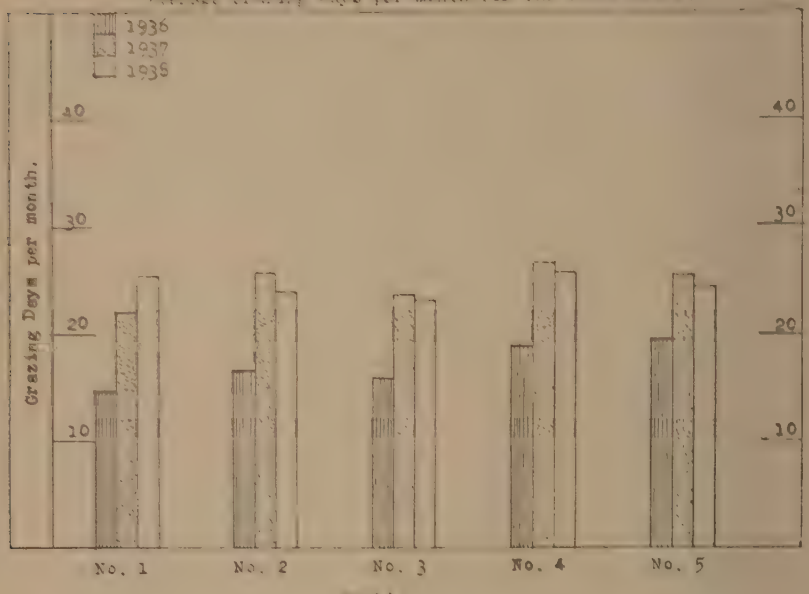
From this graph it will be seen that the actual grazing obtained for the year was slightly lower than that obtained during the previous year. This was due to lack of efficient grazing, more particularly in the late winter and spring months. Relatively good grazing was obtained for the month of May, whereas

during the previous two seasons none had been obtained for that month. No grazing was carried out in August and very little for the months of July, September, and October. The effect of under grazing was very noticeable in October and November, when the pasture became too high and rank for efficient grazing, and wastage occurring when grazing was carried out.

The various grass species in association with white clover gave the average grazing days per month for the years 1936, 1937, and 1938 as shown on Graph 7.

Graph 7.

Average Grazing Days per month for the Three Years.



It will be observed from this graph that each species gave practically no variation in grazing days per month for the two seasons, this again being due to the grazing system adopted by the farmer during the year.

Graph 8 shows the three-monthly seasonal grazing days for the five fields for years 1936, 1937, and 1938.

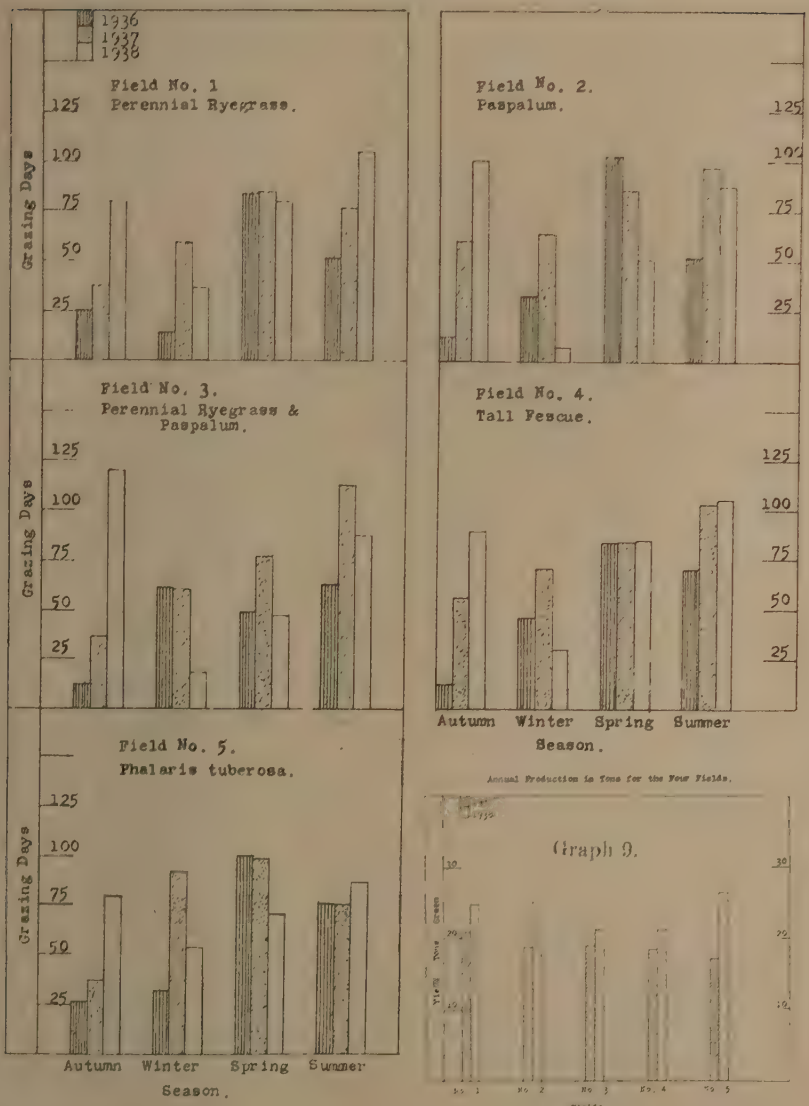
From these five series of graphs in Graph 8 it will be seen that the autumn grazing has increased considerably over the last three years on all fields, Field 3 giving the greatest increase for 1938, due to efficient grazing. The winter grazing, however, decreased considerably on all fields during 1938, although a good increase was recorded, with the exception of Field 5, for 1937, due to too light grazing during the winter of 1938.

The decrease in efficient grazing commenced in May, 1938, this naturally affecting the winter, spring, and to some extent the summer grazing production, consequently no definite information can be gleaned from these figures.

The yields of green material, however, do indicate the actual variations which occurred during the past two seasons, as is shown plainly in Graphs Nos. 9 and 10.

Graph 8.

Three-Monthly Seasonal Grazing Days for the Five Fields



Graph 9.

Yield of Green Material.

Graph No. 9 above gives the yield of green material per acre for the five fields for the two years.

It will be seen from Graph No. 9 that good increases in yields were obtained from Fields Nos. 1, 2, and 5, while Fields Nos. 3 and 4 only gave a small increase. The highest increase was recorded from Field No. 5 Phalaris tuberosa. This

grass has shown a considerable thickening up of stand with the white clover and is now a complete sward. The average production per acre from all fields has increased from 18.9 tons in 1937 to 23.9 tons in 1938.

The following Table 3 gives the production per acre for the three-monthly seasons of the years 1937 and 1938:—

Table 3.

Season.	Tons of Green Material per Acre. 1937.	1938.
Autumn	5.4	5.4
Winter	2.0	4.5
Spring	6.4	8.2
Summer	6.8	5.8

The winter production has shown a decided increase over that of the previous season. This increase is very pleasing, as it is a season of normal low production. The spring production increased from 6.4 tons to 8.2 tons per acre, while the autumn production remained constant, and the summer yield was slightly lower than that of the previous year.

Graph No. 10 (page 49) shows the three-monthly yields for the different seasons of the year for each field. As will be seen, practically no variations occurred on the individual fields for the autumn months, but in every case there was a decided increase in the winter production, Field No. 1 showing the greatest increase, and Field No. 3 giving the least, this being due in part to the still high amount of couch grass present and the lack of complete cover by white clover.

Grateful acknowledgment is made to Mr. K. T. Lutz, Agricultural Adviser, for assisting in collecting the field information given in this article.

TENTATIVE CONCLUSIONS.

The results of the last three years show that—

1. The growth of white clover during the first year of establishment may be checked seriously by the more rapid growth of perennial plants, particularly perennial rye grass. This condition can be avoided to a great extent by not seeding in excess of 4 lbs. of perennial rye grass per acre, and by efficiently controlling the grazing during the initial season. A good mixed sward, however, is usually obtained the following year.

2. Observations indicate that, where under-grazing has taken place, grass species have tended to "take charge" to the detriment of white clover. This occurs more seriously where paspalum and couch grass are the associated species. Where excessive over-grazing occurs during the summer and winter months, the reverse takes place. White clover will tend to predominate to the exclusion of such associated species as perennial rye grass, Phalaris tuberosa, and cocksfoot.

3. Phalaris tuberosa and white clover associate well under irrigated condition, provided rotational grazing is efficiently managed.

4. Paspalum and white clover can be established rapidly under irrigated conditions. Careful late spring and summer grazing is necessary, otherwise the paspalum will become "tussocky."

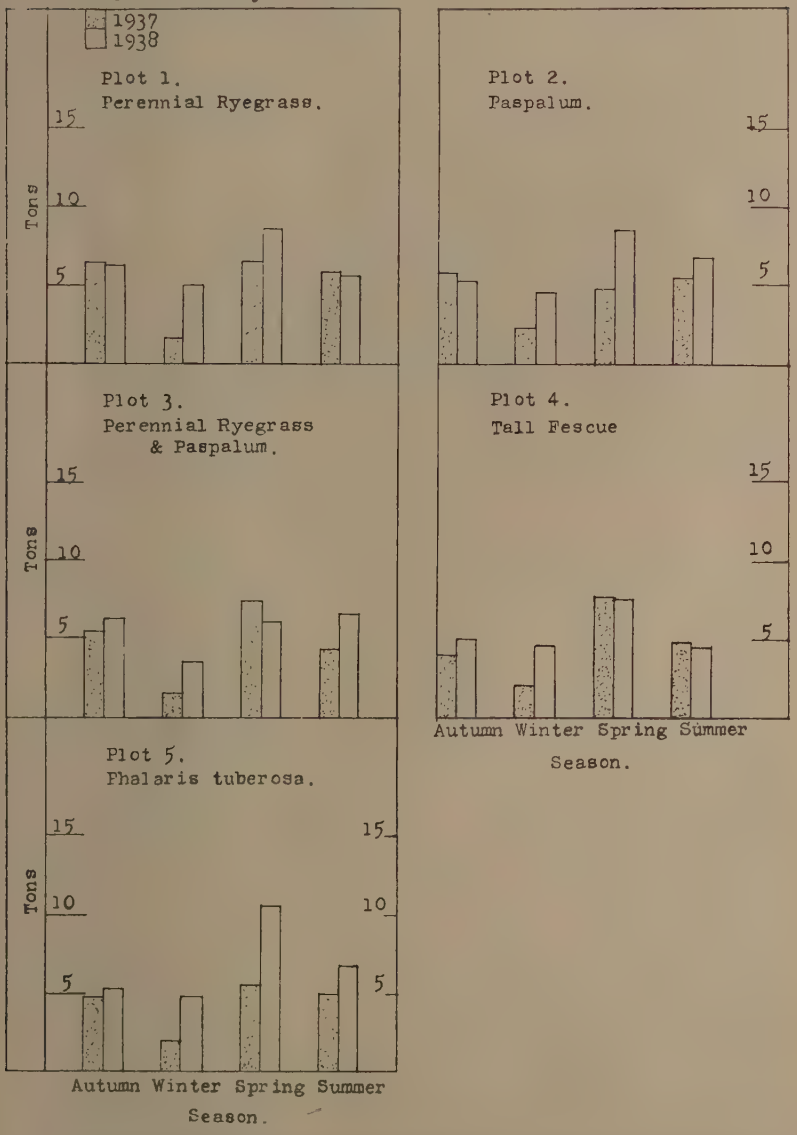
5. A mixture of cocksfoot and white clover is proving successful under existing conditions, but cannot be recommended yet for general adoption.

6. Further work on the management of tall fescue is necessary before this grass can be recommended for inclusion in a mixture for irrigated land, owing to its tendency to become "tussocky."

7. Perennial rye grass and cocksfoot association with paspalum and white clover appears to assist in preventing matting of the pasture, thereby assisting in maintaining a prolific sward.

Graph 10.

Three-Monthly Seasonal Yields for the Five Fields.



8. Winter and spring harrowing is essential to break up and distribute animal droppings. Topping with a mower during the late spring is beneficial.

9. Surface renovation is essential on paspalum pastures to maintain an adequate proportion of clover growth.

10. At least 5 cwt. of superphosphate per acre should be applied in three applications per annum on irrigated land, the heaviest application being given in the autumn.

GRADING AND MARKETING OF TOBACCO LEAF.

A. Sharp,
Tobacco Adviser.

No matter how careful the tobacco grower may have been in the cultivation, harvesting and curing of his crop, he will find that his bulks contain leaf of a number of different types. In the first place, the leaf can be divided broadly into three classes, viz. bottom, middle and top, according to the position in which it grew on the plant. Under Western Australian conditions, bottom leaf is usually fairly thin, sometimes inclined to be papery and lacking in body, and is almost invariably damaged to a greater or less extent by blue mould, grasshopper injury, etc. The leaf from the middle portion of the plant is the best, while the top leaf is smaller, rather narrow in proportion to its length, and has a tendency to be coarse.

Within each of these classes will be found considerable variation in colour, from the much-prized "Lemon" and "Bright Mahogany," down through "Mahogany" to "Dark" and "Green." As the different types of leaf are required by the manufacturers for different purposes, it is necessary for the grower to sort them carefully into grades if he is to receive the highest financial returns for his crop. The principal manufacturing firms in Australia now insist that all leaf be properly graded and handed before being offered for sale, and there is little doubt that the unsatisfactory prices obtained by some growers in the past have been due to careless grading and lack of attention to detail in the "get up" of the leaf generally.

THE GRADING SHED.

The first requirement for good grading is a properly constructed grading shed of ample size. Such a shed need not be of elaborate construction, but there are one or two points which should be borne in mind when designing it. It is usual to combine the bulk and grading shed under one roof. As grading is carried out mainly during the months of May, June and July, when heavy and continuous rain may be expected, it is advisable to have the shed built well off the ground and to have it lined either with asbestos-cement sheets or some other damp-proof material, otherwise the leaf is liable to absorb an excessive amount of moisture during handling with consequent risk of developing mould. The south wall of the shed should be fitted with ample window space so that plenty of diffused light can fall on the grading bench. It is extremely important that the direct rays of the sun should not be allowed to fall on the leaf, as its true colour cannot be judged in direct sunlight. The only equipment required is a grading bench or benches fitted with compartments for holding the various grades of leaf.

GRADING.

The quality of tobacco leaf is determined, for buying purposes, by its colour, texture, size and soundness, and of these, colour is the most important. At present, grading is carried out almost entirely on a colour basis. This does not necessarily mean that the light-coloured leaf which fetches the highest price ultimately produces the best "smoke," but the present fashion demands this type and it is therefore the grower's business to meet that demand as far as possible.

The number of grades into which the leaf is sorted will depend on the uniformity or otherwise of the crop. Generally speaking, it will be found that seven colour grades will be sufficient to meet the buyers' requirements. These grades might be described as follows:—

(1) First Grade Bright Mahogany (BM1).—Clear bright yellow or slightly orange colour, sound and free from blemish and of good texture, *i.e.*, having plenty of toughness and elasticity. Must not show any green tinge.

(2) Second Grade Bright Mahogany (BM2).—Very slightly darker than BM1 and of good texture. Small amount of sponging and other blemishes permissible, but must not show any tinge of green.

(3) Third Grade Bright Mahogany (BM3).—Slightly darker than BM2, good texture, and may carry a proportion of less sound, sponged and blemished leaf. No leaf showing green should be included.

(4) Inferior Bright (IB).—Will include all leaf of bright mahogany colour which is too badly blemished and broken to be included in the first three grades.

(5) Mahogany (M).—Reddish brown colour, may be somewhat sponged and blemished, but thoroughly mature and showing no green.

(6) Dark Mahogany (D).—Very dark brown, coarse-textured leaf, usually from the top of the plant.

(7) Green (G).—All leaf showing the least tinge of green.

It will be noted that no mention is made here of a "Lemon" grade. The amount of leaf produced in most Western Australian crops which can be classed as lemon is so small that it is hardly worth while making a separate grade of it, whereas if it is included as BM1 it will tend to improve the general appearance of that grade.

It is very doubtful whether the sixth grade mentioned here (Dark Mahogany) will be saleable in future. Under the conditions obtaining at Manjimup, leaf which fails to cure a bright colour has usually been spoilt through exposure to adverse weather conditions or has been picked in an immature condition. Such leaf can be used by manufacturers only in very small quantities.

The seventh grade (Green) may be divided into two parts:—

(1) Bright leaf showing only a faint tinge of green.

(2) Leaf showing a definite amount of green.

These should be bulked separately until the whole of the crop has been graded, when the first grade greens can be gone through again, when it will probably be found that much of the green tinge has disappeared, and the leaf can be regraded into the various bright mahogany grades.

Another grade which may have to be included in the case of some crops is for leaf of good colour but of harsh, woody texture. Such leaf may have quite good smoking characteristics as raw leaf, but it has been found that it refuses to respond to the various manufacturing processes, and buyers insist that its presence in the bright mahogany grades is highly detrimental. Leaf of this description should therefore be rigidly excluded from the higher grades.

In addition to grading for colour, the leaf should be sorted according to size. In the case of moderate crops having no very large leaf, two sizes will be sufficient—medium and small—but where the crop includes leaf over, say, twenty inches in length it is advisable to include three sizes. All leaf under 12 inches in length should be classed as "small" and handed and baled separately. Leaf over 12 inches in length should be divided into "medium" and "large" and tied up separately but may be baled together.

Grading should not commence until the leaf has been at least five or six weeks in the bulk. Under the weather conditions experienced in this State it is impossible to start grading in any case until the autumn rains have started in April, unless steps are taken to artificially humidify the atmosphere of the grading shed, so that most of the leaf is actually over two months in bulk before being graded.

It frequently happens that the leaf in the bulk is found to be rather too dry to permit of being handled without breaking. If it has been bulked "on the stick" it is a simple matter to hang up a sufficient quantity overnight for the following day's grading, when it will usually be found that sufficient moisture has been absorbed to soften it. Should the leaf have been bulked off the stick, the best plan is to turn the bulk during wet weather a short time before grading is due to commence.

HANDING.

When the leaf has been sorted into the various grades it is tied into hands, each containing from a dozen to twenty leaves according to size. The butts of the finished hands should not be more than one inch in diameter. When made larger than this they look untidy and are liable to fall apart on handling. To tie a hand, a leaf of the same grade is folded along the midrib, with the upper surface to the outside, and wrapped tightly round the butts of the leaves several times, the butt end then being tucked into the middle of the hand. When finished, the tie leaf should extend from just beyond the extreme end of the butts to about 1½ to 2 inches down the hand. Neatly tied hands of the proper size help very greatly to show the leaf off to advantage.

After being tied into hands the leaf is again bulked until sufficient has accumulated to fill a bale, care being taken not to get the grades mixed. These loose bulks should be kept carefully covered to prevent the absorption of too much moisture by the leaf.

BALING.

The standard size bale in use in this State measures 36in. x 22in. x 18in. and contains about 180 lbs. of leaf. It should be wrapped in new 14oz. hessian. A lining of brown paper is sometimes used inside the hessian but is not necessary. In baling, a length of hessian 3 feet wide and long enough to go right round the bale with a few inches overlap is placed on the floor of the press, the sides of which are then fixed in position. The hands are placed with the butts towards the two ends of the bale, a layer being placed at each end alternately and a binding layer being built into the centre as required. All leaf must lie along the length of the bale; on no account should the binding layers be placed crosswise.

Having filled the press, the lid is laid in position and pressure applied by means of a screw or jack. This first pressure reduces the volume of the leaf by about half. The pressure is released after a few minutes, the lid removed, and the press again filled with leaf, after which pressure is again applied. The completed bale should be left under pressure for at least one hour, otherwise the natural spring of the leaf will cause it to lose compactness. If the tobacco is to be stored on the farm pending the visit of the buyers—as is usually the case in this State—the bale should not be stitched, but should be simply held together by means of three ropes passed round it and tied firmly. This allows of easy examination by the buyer and the replacement of the sample hands drawn for inspection. After purchase, the bales can be stitched, the ropes removed, and the caps sewn on the ends. The ropes should not be left on the bales as their presence during transport tends to injure a portion of the leaf.

As far as possible, only one grade of leaf should be placed in any one bale. If small parcels of various grades are left over, however, it is permissible to make up a bale of two, or even three, grades, placing a layer of paper between them. Bright and dark leaf, however, should not be included in the same bale.

Before despatch to the factory, each bale should be clearly stencilled with the grower's brand, the buyer's grade mark, and the buying company's brand. All marks should appear on one side of the bale only.

MARKETING OF LEAF.

The system of marketing the leaf grown in this State by the small private growers has hitherto been that known as "farm buying." Under this system the buyer visits each grower, usually in July or August, and closely inspects a number of hands drawn from each bale. A price is offered for each grade of useable leaf and, if acceptable to the grower, the sale is finalised on the spot and the grower agrees to despatch the leaf to the factory by a given date. Until the present, there

has been only one bidder from the Eastern States for the Western Australian crop, but evidence has recently been obtained that at least one other Eastern States manufacturing concern would be prepared to purchase quantities of Western Australian leaf provided that it was put up for auction.

There would appear to be little doubt that the advent of a certain amount of competition among buyers for this State's crop would place the industry on a more secure footing than has hitherto been the case, and would engender a feeling of confidence among the growers.

The system of farm buying suffers from a number of rather serious disadvantages, apart from the absence of competition for the leaf. Very few growers in Western Australia have sufficient well lighted shed accommodation to set out their crop to proper advantage. More often than not the sample hands on which prices are appraised have to be taken into the open air for examination, and during wet weather the conditions under which the buyers operate can be rather uncomfortable. The system also involves a great deal of travelling on the part of the buyers, frequently over rather indifferent roads and bush tracks, and it is only reasonable to suppose that the quite considerable expense involved is reflected in a somewhat lower price being offered for the leaf than might otherwise be the case. Another serious disability lies in the fact that the average grower has little opportunity of comparing the quality and "get up" of his crop with that of others, and when he fails to receive what he considers a satisfactory price for his leaf he is inclined to blame the judgment of the buyer rather than to realise that his methods of handling his leaf have been faulty.

The system of sale by auction, which has been in vogue in Queensland for a number of years, would appear to be a definite advance on farm buying. Under this system, the crop, after grading, handing and baling, would be despatched to one or other of the big wool-selling floors at Fremantle, where it would be set out for inspection under ideal conditions. The buyers would have ample opportunity to appraise each lot carefully, and the whole Western Australian crop could probably be disposed of expeditiously at a single auction. Growers would also have the opportunity of meeting each other on the floor and of inspecting the grading and "get up" of crops other than their own. This would undoubtedly tend towards improvement and standardisation of the crop as a whole.

PIG FEEDING EXPERIMENT—MURESK AGRICULTURAL COLLEGE.

SUPPLEMENTS SUITABLE FOR FEEDING WITH WHEAT.

H. J. Hughes, B.A., Late Principal; C. R. Dixon, Pig Husbandryman.

The following feeding experiments, which were originally designed as a demonstration to farmers attending the Short Winter Course last August at The Muresk College, have given such valuable and interesting results, that it has been thought desirable to make the information available to all farmers through this Journal.

Six groups of pigs were selected, each group containing four or five pigs, as nearly matched for weight and quality as possible. Each individual pig was marked for identification, and weighed at seven-day intervals throughout the feeding period, which was 16 weeks.

The pigs selected were weaners and all first crosses of the Tamworth and Berkshire breeds.

The rations fed to the various groups were as follow:—

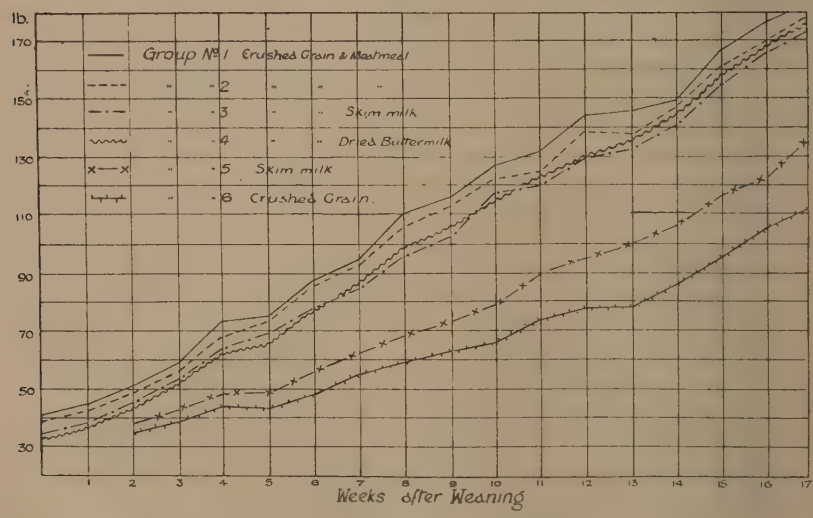
Group 1.—Crushed wheat with meat meal.
Group 2.—Crushed wheat with meat meal.
Group 3.—Crushed wheat with skimmed milk.
Group 4.—Crushed wheat with dried butter milk.
Group 5.—Skimmed milk only.
Group 6.—Crushed wheat only.

All pigs received a quantity of green fodder daily, and were allowed access to a suitable run for exercise.

The proportions of the various supplements fed with the crushed wheat are shown in table 1. It will be noticed that the quantity of these supplements remained practically constant, indicating that the young pig requires a ration relatively high in protein in comparison with its requirements as bacon weights are reached.

Until the eleventh week after weaning the rations were increased at fortnightly intervals, after which it was found desirable to increase the daily ration each week. As in most cases where stock are being fed, it was found that individual animals were outstanding in their capacity to convert the food they consumed into meat, and indicates the great advantages which might accrue from a consistent policy of selection from those families which produce such individuals for breeding stock. The average results however of each group are a more true record of what might be expected in practice, and are shown for convenience in graph form below, which brings out the salient differences between the groups more clearly than figures.

A COMPARISON OF SUPPLEMENTS FOR FEEDING WITH WHEAT TO PIGS.



A study of this graph shows a number of interesting points:—

1. It will be noticed that the four groups receiving crushed wheat and a suitable concentrate were for practical purposes equal in their rate of growth. The two groups receiving meat meal for their concentrate were slightly heavier at the start

Table I.

RATIONS FED TO PIGS IN EACH GROUP.

Date.	Group 1.		Group 2.		Group 3.		Group 4.		Group 5.	Group 6.
	Per Pig per day.		Per Pig per day.		Per Pig per day.		Per Pig per day.		Per Pig per day.	Per Pig per day.
	Grain.	Meatmeal.	Grain.	Meatmeal.	Grain.	Skim Milk.	Grain.	Buttermilk (Dried).	Skim Milk (only).	Grain (only).
	lbs.	lbs.	lbs.	lbs.	lbs.	gall.	lbs.	lbs.	gall.	lbs.
27th May–3rd June	½	¼	½	¼	½	½	½	¼	...	...
3rd–10th June	1	½	1	½	1	¾	1	½	...	...
10th–17th June	1½	½	1½	½	1½	¾	1½	½	¾	¾
17th–24th June	2	½	2	½	2	¾	2	½	1	1
24th–1st July	2	½	2	½	2	¾	2	½	1¼	1¼
1st–8th July	2½	½	2½	½	2½	¾	2½	½	1½	1½
8th–15th July	2½	½	2½	½	2½	¾	2½	½	1¾	1¾
15th–22nd July	3	½	3	½	3	¾	3	½	1¾	2
22nd–29th July	3	½	3	½	3	¾	3	½	2	2½
29th July–5th August	3½	½	3½	½	3½	¾	3½	½	2	2½
5th–12th August	3½	½	3½	½	3½	¾	3½	½	2½	3
12th–19th August	4	½	4	½	4	¾	4	½	2½	3½
19th–26th August	4½	½	4½	½	4½	¾	4½	½	3	3½
26th August–2nd September ...	5	½	5	½	5	1	5	½	3	4
2nd–9th September	5½	½	5½	½	5½	1	5½	½	3½	4¼
9th–16th September	6	½	6	½	6	1	6	½	4	4½
16th–23rd September	6½	½	6½	½	6½	1	6½	½	4½	5

than the groups receiving skim milk or dried butter milk, and these groups finished the feeding experiment with approximately the same difference between the average weights.

2. Half a pound of dried butter milk was equivalent to approximately three-quarters of a gallon of skimmed milk, and in turn equivalent to half a pound of meat meal.

3. Skimmed milk, with green material, is not an efficient ration for growing pigs. Although this group was fed for two weeks less than the groups 1-4, even if the rate of growth had been maintained for another two weeks these pigs would have been about twenty pounds lighter than in the other four groups. Apart from this, however, it was noticeable that although these skim milk fed pigs appeared sleek they were "big bellied" and soft in appearance, and experience has shown that they would kill out too fat and "soft."

4. The wheat only fed pigs were obviously unhealthy all through the fourteen weeks that they were being fed. Their coats were rough and the pigs had the appearance aptly described as "pot-bellied." One of these pigs was killed for demonstration purposes about three months after the feeding began and besides being very stunted in growth showed a carcase which was far too high in fat for trade requirements. This group showed an average weight which was approximately 60 lbs. less than the pigs in group 1 at the same age, which received meat meal as a supplement. It can safely be said that although skim milk alone may eventually produce a pig which is saleable as a bacon pig, although not of prime quality, pigs fed on wheat alone never will produce a bacon pig which is saleable at a reasonable price.

5. It will be noticed that the curves showing the average growth per week for each group, do not rise at a constant rate. This is more particularly the case with groups 1 and 2, and to a lesser extent with group 3, receiving skim milk.

This is an indication of the care and attention to the individual requirements of pigs necessary by attendants if the best results are to be obtained. From the 27th May to 12th August, or for eleven weeks, the ration was increased each fortnight and for the first month this practice gave good results. After this period however, and as a result of weighing the pigs weekly and comparing the weights, it was noticed that some groups seemed to grow more rapidly for a week and then slow down for a week, as is shown by the steps in the graph. These slow periods of growth were found to coincide with the second week of the ration period, more rapid growth taking place during the following week when the ration was increased. From the twelfth week, however, the rations were increased each week, and it will be noticed that the graph continued in an almost smooth upward curve for all groups after this time.

Although the only way of ascertaining that pigs are being economically fed is to weigh regularly, this may not always be possible in practice, but feeders should be careful to see that pigs are receiving an adequate ration, which can be ensured by feeding regularly at least twice per day and as much as they can clean up in about 15 minutes. The self feeding of pigs of course does away with this supervision to a great extent.

Cost of Supplements.

In all feeding trials two aspects must be considered, firstly, the suitability of the ration for the purpose for which it is being used, and secondly the cost of that ration. The present experiments give some interesting information on the cost of feeding pigs under wheatbelt conditions, in comparison with those in dairy districts.

Tables 2 to 8 below have been prepared to show this information.

Table 2.

	Group I.	Group II.	Group III.	Group IV.	Group V.	Group VI.
Average weight at weaning (lbs.) ...	40	39	35	32	39	36
Average weight at end of experiment (lbs.)	181	178	173	177	135	111
Average gain per pig (lbs.) ...	141	139	138	145	96	75
Weight of crushed wheat consumed per pig (lbs.)	396	396	396	396	...	295
Weight of meatmeal consumed per pig (lbs.)	58	58	...	...	...	...
Weight of butter-milk (dried) consumed per pig (lbs.)	...	...	...	58	...	...
Gallons of skim-milk consumed per pig	...	...	88	...	243	...
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Total cost of feed per pig ...	1 11 2	1 11 2	1 12 3	1 17 6	1 0 3	0 18 5
Weight of feed per lb. live weight gain (lbs.)	3·24	3·26	3·52	3·13	2·53	3·93
Average cost per lb. live weight gain (pence)	2·67	2·69	2·80	3·10	2·53	2·94

REMARKS :—

GROUP I.—Fed crushed wheat and meat meal—healthy and vigorous.

GROUP II.—Fed crushed wheat and meat meal. Very even group. Three pigs out of this group were judged first in the Royal Show Export Baconer Class.

GROUP III.—Fed crushed wheat and skim milk. Selected from same litter as Group II. Bigger variation in individual weights than in Group II.

GROUP IV.—Fed crushed wheat and dried butter-milk. Most robust of the six pens. Skin and hair of better appearance than above Groups.

Group V.—Fed skim milk only. Unthrifty appearance, long-haired and slightly pot-bellied.

GROUP VI.—Fed crushed wheat only. Sickly, stunted appearance. Worst appearance of all the groups. Long-haired and pot-bellied.

Table 3.

GROUP I.

CRUSHED WHEAT AND MEAT MEAL.

Weight Week ending	No. 1. lbs.	No. 2. lbs.	No. 3. lbs.	No. 4. lbs.	Average. lbs.	Average Gain. lbs.
27th May	41	42	35	45	40·33	...
3rd June	45	46	38	49	44	3·66
10th June	50	54	46	56	50·66	6·66
17th June	59	60	53	66	59·33	8·66
24th June	74	72	66	79	73	13·66
1st July	77	77	70	81	76	3
8th July	89	91	83	93	88·33	12·33
15th July	95	97	90	101	95·33	7
22nd July	111	111	105	114	110	14·66
29th July	118	117	112	119	116·33	6·33
5th August ...	127	131	125	130	127·66	11
12th August ...	131	137	128	135	131·33	4
19th August ...	145	Killed for	141	146	144	12·66
26th August ...	146	demonstra-	144	147	145·66	1·66
2nd September ...	147	tion	149	152	149·33	3·66
9th September ...	164		164	171	166·33	17
16th September ...	175		179	182	178·66	12·33
23rd September ...	177		179	187	181	2·33

Table 4.

Group II.

CRUSHED WHEAT AND MEAT MEAL.

Weight Week ending	No. 1 lbs.	No. 2. lbs.	No. 3. lbs.	No. 4. lbs.	No. 5. lbs.	Average lbs.	Average Gain lbs.
27th May	46	39	38	38	34	39	...
3rd June	49	42	40	42	36	41·8	2·8
10th June	54	48	46	48	44	48	6·2
17th June	62	57	55	56	52	56·4	8·4
24th June	76	68	66	68	63	68·2	11·8
1st July	80	72	71	74	68	73	4·8
8th July	93	87	83	88	82	86·6	13·6
15th July	96	94	88	95	88	92·2	5·6
22nd July	110	107	104	109	99	105·8	13·6
29th July	116	112	112	114	104	111·6	5·8
5th August	127	123	122	125	114	122·2	10·6
12th August	131	124	125	127	115	124·4	2·2
19th August	146	140	139	140	129	138·8	14·4
26th August	146	140	141	139	126	138·4	–0·4
2nd September	154	149	149	148	137	147·4	9·0
9th September	168	161	163	163	149	160·8	13·4
16th September ...	177	168	173	173	157	169·6	8·8
23rd September ...	183	177	180	181	167	177·6	8·0

Table 5.

Group III.

CRUSHED WHEAT AND SKIM MILK.

Weight Week ending	No. 1. lbs.	No. 2. lbs.	No. 3. lbs.	No. 4. lbs.	No. 5. lbs.	Average lbs.	Average Gain lbs.
27th May	44	31	36	34	28	34·6	...
3rd June	48	35	38	39	32	38·4	3·8
10th June	57	42	47	46	40	46·4	8·0
17th June	62	48	54	54	46	52·8	6·4
24th June	76	58	63	66	53	63·2	10·4
1st July	86	60	71	72	57	69·2	6·0
8th July	92	68	82	82	66	78	8·8
15th July	98	74	91	86	76	84·2	6·2
22nd July	108	86	104	98	84	96	11·8
29th July	114	94	111	104	88	102·2	6·2
5th August	129	108	128	119	100	116·8	14·6
12th August	132	114	130	120	104	120	3·2
19th August	139	120	141	130	114	128·8	8·8
26th August	145	128	146	136	108	132·6	3·8
2nd September	150	135	150	143	124	140·4	7·8
9th September	164	159	165	155	134	155·4	15·0
16th September ...	178	165	175	169	145	166·4	11·0
23rd September ...	186	172	180	175	154	173·4	7·0

Table 6.

Group IV.

CRUSHED WHEAT AND DRIED BUTTER-MILK.

Weight Week ending	No. 1. lbs.	No. 2. lbs.	No. 3. lbs.	No. 4. lbs.	Average lbs.	Average Gain lbs.
27th May	33	32	33	31	32·25	...
3rd June	37	37	38	36	37	4·75
10th June	45	44	46	42	44·25	7·25
17th June	52	52	54	50	52	7·75
24th June	62	62	67	57	62	10·0

Table 6—*continued.*

Group IV.—*continued.*

Crushed Wheat and Dried Butter-Milk—*continued.*

Weight Week ending	No. 1. lbs.	No. 2. lbs.	No. 3. lbs.	No. 4. lbs.	Average lbs.	Average Gain lbs.
1st July	69	64	72	62	66·75	4·75
8th July	80	76	83	72	77·75	11·0
15th July	91	85	90	79	86·25	8·5
22nd July	105	98	102	90	98·75	12·5
29th July	111	104	109	97	105·25	6·5
5th August ...	124	114	122	108	114·25	9·0
12th August ...	130	123	126	111	122·5	8·25
19th August ...	138	130	135	115	129·5	7·0
26th August ...	142	133	143	121	134·75	5·25
2nd September ...	153	144	153	132	145·5	10·75
9th September ...	166	157	166	143	158	12·5
16th September ...	179	167	179	150	168·75	10·75
23rd September ...	188	172	191	157	177	8·25

Table 7.

Group V.

SKIM MILK ONLY.

Weight Week ending.	No. 1. lbs.	No. 2. lbs.	No. 3. lbs.	No. 4. lbs.	Average lbs.	Average Gain lbs.
10th June	40	38	38	39	38·75	...
17th June	43	43	43	41	42·5	3·75
24th June	50	48	48	46	48	5·5
1st July	50	49	49	48	49	1·0
8th July	56	57	56	56	56·25	7·25
15th July	65	63	61	61	62·5	6·25
22nd July	69	69	67	66	67·75	5·25
29th July	72	75	72	72	72·75	5·0
5th August ...	80	82	81	73	79	6·25
12th August ...	92	92	90	85	89·75	10·75
19th August ...	96	98	95	93	95·5	5·75
26th August ...	99	103	101	97	100	4·5
2nd September ...	105	110	108	104	106·25	6·75
9th September ...	114	116	120	116	116·5	9·75
16th September ...	121	120	125	122	122	5·5
23rd September ...	132	134	137	137	135	13·0

Table 8.

Group VI.

CRUSHED WHEAT ONLY.

Weight Week ending	No. 1. lbs.	No. 2. lbs.	No. 3. lbs.	No. 4. lbs.	Average lbs.	Average Gain lbs.
10th June	33	39	35	40	35·66	...
17th June	35	42	38	43	38·33	2·66
24th June	41	48	45	50	44·66	6·33
1st July	39	48	45	50	44	—0·66
8th July	41	58	47	56	48·66	4·66
15th July	47	65	54	62	55·33	6·66
22nd July	50	70	58	67	59·33	4·0
29th July	53	76	61	70	63·33	4·0
5th August ...	55	81	63	80	66·33	3·0
12th August ...	59	92	69	87	73·33	7·0
19th August ...	62	98	71	Killed for	77·0	3·66
26th August ...	64	97	71	demonstra-	77·33	0·33
2nd September ...	70	109	80	tion	86·33	9·0
9th September ...	77	124	86		95·66	9·33
16th September ...	83	138	94		105·0	9·33
23rd September ...	90	143	99		110·66	5·66

Tables 3 to 8 show that in groups 1-4, the daily gains of the pigs were approximately constant, the slight favour in the case of the dried milk group not being significant. This average gain of approximately 1.2 lbs. per days is rather greater than is obtained in most commercial piggeries and is quite satisfactory.

In the case of groups 5 and 6, however, receiving respectively skim milk only and wheat only, the daily gains are distinctly lower, being most unsatisfactory in the case of wheat only pigs. This is an excellent demonstration of the losses which are being experienced in the two types of districts represented by these uneconomical rations, namely, the dairy belt and the wheat belt. Attendance at almost any large pig sale will reveal that many pigs are still being fed on these poorly balanced rations, with loss not only to the grower, but also to the purchaser, who endeavours however to safeguard himself against loss by giving a reduced price for such animals.

Table 2 sets out clearly the costs of the various rations used and indicates that with wheat at 3s. 9d., which was the average price during the experiment, and skim milk at 1d. gallon there is practically no difference in the cost of raising bacon pigs in the wheat belt or in the dairy districts, namely, 31s. 2d. and 32s. 3d. respectively.

Dried buttermilk, however, which was donated by the South-West Co-operative Dairy Farmers Ltd., although efficient as a substitute for skim milk, proved more costly at a market price of £24 16s. per long ton. The pigs in this group cost 37s. 6d. for their ration, without green stuff, but would have returned a handsome profit to the feeder at prices ruling during the experiment.

It will be noticed that the quantity of skim milk fed with the crushed wheat was approximately 2¼ lbs. for each 1 lb. of grain, which is considerably less than is usually fed on farms where skim milk is available, but the intention was to feed the skim milk so that the utmost use could be made of the supply available, and it is believed that the most profit would be made from skim milk by feeding it in such a proportion. This would, of course, mean that more pigs would have to be fattened per cow than is the custom to-day, but should mean, especially while present prices continue, that profits from this source of revenue on dairy farms would be greater.

It will also be noticed that approximately 6½ bushels of wheat is required to grow a pig from a weaner weight of 36-40 lbs. to a live weight of approximately 180 lbs. corresponding to a carcase weight of about 130 lbs. for pigs finished with such rations.

It is of interest to record that three pigs from group No. 2 were entered for the Perpetual Executors trophy for pen of 3 Export Bacon Pigs at the Royal Show last year, and were successful in gaining first place, scoring particularly well in the points awarded for suitability of carcase after slaughter.

The writers desire to express their thanks to the Superintendent of Dairying, Mr. G. K. Baron-Hay, for suggesting the above experiments, and for assistance in tabulating and preparing the above information for publication.

THE INFLUENCE OF METHODS OF PLANTING ON THE EFFECTIVE INOCULATION AND ESTABLISHMENT OF SUBTERRANEAN CLOVER.

INOCULATION EXPERIMENTS, 1938.

W. P. Cass Smith, Plant Pathologist.
H. A. J. Pittman.*

Introduction.

EXPERIMENT I.

Of recent years in Western Australia the necessity for establishing suitable leguminous pastures for the development of our livestock industries, and for the improvement of soil fertility, has been emphasised in many quarters. Figures supplied by the Government Statistician show that this need is widely appreciated, for in 1932 the area under sown pasture was only 430,547 acres, whereas in 1937 the area had been increased to 741,688 acres, the sowing during this latter year alone exceeding 100,000 acres.

As these pastures, which consist very largely of subterranean clover, are initially established on virgin soils where the requisite rhizobial bacteria for effective inoculation are likely to be lacking, the introduction of the bacteria to the soil with the seed at planting time is generally essential if healthy vigorous stands are speedily to be obtained.

Fairly effective plant inoculation appears to have been secured in certain instances by sowing badly cleaned samples of seed, containing soil particles carrying the bacteria, but the risk of spreading weeds, diseases and insect pests, such as red mite (*Halotydeus destructor*) and lucerne flea (*Sminthuris viridis*) incurred in this method of introducing the root nodule bacteria to the soil, is a serious disadvantage from which the method of pure-culture seed-inoculation does not suffer.

The necessity for inoculating seeds of the true clovers (*Trifolium* sp.) and other legumes such as peas, lupins, lucerne, beans, etc., with effective strains of root nodule bacteria prior to planting new areas, is now well recognised in W.A., for during the year ending June 30, 1938, some 1,700 bacterial cultures were supplied by the Department of Agriculture, at small charges, to farmers for this purpose.

The number of each kind of culture, the quantities of seed this would inoculate (at rates of inoculation recommended to farmers), together with the sown acreages this represents, is shown in Table 1.

TABLE 1.

Pure Culture Strain of Rhizobium	No. and kind of culture supplied, 1937–38.	Lbs. of Seed this total would Inoculate.	Acreage this total would Sow at Average Sowing Rates.
		lbs.	acres.
Clover	958	80,640	40,320
Pea	337	40,290	896
Lucerne	195	9,105	1,138
Lupin	98	15,970	1,058
Tangier Pea	45	2,820	940
Cow Pea	27	1,380	92
French Bean	19	840	8
Lotus	13	210	105
Soya Bean	6	210	7
Lespedeza	2	30	10
	1,700	151,395	44,574

* Formerly Plant Pathologist. Resigned on August 23, 1938, to become Principal, Dookie Agricultural College, Victoria.

Numerous reports from farmers indicate that excellent results have been obtained by seed inoculation prior to planting, but a number of failures have also occurred, particularly with subterranean clover. These, apart from adverse seasonal conditions, have been traced in almost every instance to *faulty sowing methods and particularly to the mixing of inoculated seed with superphosphate prior to planting*, this procedure nullifying the beneficial effect of the bacteria. From both practical and theoretical considerations, therefore, it has been the recommendation of this Department for a number of years that pure-culture-inoculated seed should be sown separately from the superphosphate fertiliser unless the seed and fertiliser were sown immediately after mixing on a wet seed bed (1).

Reid (2) has demonstrated in New Zealand that mixing inoculated lucerne seed with superphosphate before sowing killed the bacteria, but mixing with basic superphosphate produced better results. In Western Australia also, one farmer* with many years' experience in the establishment of subterranean clover, reported that in his district, where inoculated subterranean clover seed has been mixed with basic superphosphate before planting, infinitely better results have been obtained than where superphosphate has been used.

As subterranean clover is destined to play an increasingly important part in developing new areas of land in this State for pasture purposes, and as large numbers of cultures are being supplied by this Department for clover seed inoculation (see Table 1), a more accurate knowledge concerning the influence of sowing methods on effective plant inoculation seemed desirable. An experiment was therefore planned with the following main objects:—

Objects of Experiment.

(1) To test the efficiency of the subterranean clover strain of rhizobial bacteria used by this Department, by comparing the yields obtained from inoculated and uninoculated subterranean clover seed, when planted on virgin soil.

(2) To study the influence of various methods of planting inoculated subterranean clover seed in conjunction with superphosphate, on the subsequent effective plant inoculation, and to determine the best practical sowing methods.

(3) To ascertain whether mixing inoculated subterranean clover seed with superphosphate for various periods prior to planting, is more detrimental than the mixing of inoculated seed with basic superphosphate for the same periods of time.

Details of Experiment.

The experiment was conducted at Ridge Hill in the Helena Valley district of the Darling Ranges on the property of Mr. H. Larwood. The site is adjacent to the metropolitan area, and rainfall figures, taken from the nearest meteorological station, show that the mean annual rainfall is 34 inches.

The monthly precipitation during the course of the experiment was:—

May.	June.	July.	August.	September.	October.	November.	December.	Total.
205	482	639	426	325	202	125	15	2,419

The site was cleared of natural vegetation just prior to commencing the experiment; and with the exception of rhizobial bacteria specific for native legumes (which appear to be ineffective for the inoculation of most agricultural species so far grown in W.A.), the soil in this respect was thought to be completely sterile, being completely surrounded by virgin bush in which, as far as can be learned, stock had never been depastured.

Vegetation.

The vegetation in this area is typical of a large section of the Darling Range country, the dominant tree formation consisting of jarrah (*Eucalyptus marginata*)

* E. Farleigh, Esq., Rylington Park, Boyup Brook.

and marri or red gum (*E. calophylla*), sometimes intermixed with wandoo (*E. redunca* var. *elata*).

The smaller trees and shrubs are mainly represented by sclerophyllous members of the families Proteaceae Leguminoseae (particularly Papilionaceae) and Myrtaceae, together with the blackboy (*Xanthorrhoea Preissii*) and Zamia palm (*Macrozamia Reidlei*).

Soil Type.

The soil is of the podsolic type and typical of large areas of the jarrah and marri belts of the Darling Ranges (Teakle (3)) consisting of ironstone gravelly sands, the surface varying from grey brown to light brown in colour. These soils rest on a yellowish and whitish to yellowish clay layer at highly variable depths, and at greater depths kaolinised rock material is generally encountered.

The soil of the experimental area contained from 44 per cent. to 75 per cent. of gravel in the surface 3 inches and from 38 per cent. to 69 per cent. gravel in the sub-surface to a depth of 9 inches.

The soil reaction ranged from pH 5.8—pH 6.2 in this surface layer and from pH 5.9—pH 6.2 in the subsurface soil.

Lay Out, Sowing Rates, etc.

The experiment consisting of 11 *treatments was arranged in the form of a randomised block with six separately randomised replications of each treatment.*

Treatment rows were half a chain long and four links apart and each row was hoed out to a depth of three inches for the subsequent sowing therein of the seed and fertiliser.

The midseason strain of subterranean clover was used in this experiment, the seed being cleaned but unpolished. The rate of sowing was 8 lbs. per acre.

Superphosphate at the rate of 1½ cwt. per acre and basic superphosphate containing equivalent amounts of phosphoric acid per acre were applied. The superphosphate used contained 23 per cent. total phophoric acid and the basic superphosphate 17 per cent.

The treatments were as follows:—

Treatment.

(1) Superphosphate applied to the soil 48 hours before planting the uninoculated seed.
(2) Superphosphate applied to the soil 48 hours before planting the inoculated seed.
(3) Superphosphate applied and thinly covered with soil, inoculated seed, then planted immediately.
(4) Superphosphate mixed with inoculated seed, then planted immediately.
(5) Superphosphate mixed with inoculated seed and planted after contact for one hour.
(6) Superphosphate mixed with inoculated seed and planted after contact for 24 hours.
(7) Superphosphate mixed with inoculated seed and planted after contact for 48 hours.
(8) Basic superphosphate mixed with inoculated seed and planted after contact for 1 hour.
(9) Basic superphosphate mixed with inoculated seed and planted after contact for 24 hours.
(10) Basic superphosphate mixed with inoculated seed and planted after contact for 48 hours.
(11) Superphosphate applied to the soil, and seed inoculated, 48 hours before planting.
Planting of seed withheld until all other treatment plantings were completed.

The treatments were designed to represent the common methods used in practice of sowing inoculated subterranean clover seed in conjunction with phosphatic fertiliser.

PLATE 1.

Variations in the growth of Subterranean Clover illustrating the influence of planting methods in conjunction with superphosphate fertiliser on the effective inoculation obtained.

For details of treatments 1-6 see page 63.

PLATE 2.

Variations in the growth of Subterranean Clover illustrating the influence of planting methods in conjunction with superphosphate and basic superphosphate fertilisers on the effective inoculation obtained.

For details of treatments 7-11 see page 63.

An analysis of these methods shows that they can be divided into two main groups—

(1) Those in which the fertiliser does not make contact with the seed before planting.

(2) Those in which the seed and fertiliser are in contact for various periods prior to planting.

In group (1) may be placed the method in which the fertiliser is separately applied some time before the seed is planted (represented by treatments 1, 2, and 11) and the method of sowing with the "small seeds" attachment to the ordinary grain and fertiliser drill. In this method, as commonly used in W.A., the superphosphate is first covered with soil by the drill tynes, and the seed is harrowed in above the fertiliser (represented by treatment 3).

In group (2) may be placed the following methods: (a) Seed and super. sown in one operation but through separate sides of the drill box, as for example when planting subterranean clover seed mixed with the seed of a cover crop. In this method the seed comes into *momentary contact only* with the superphosphate in the drill tubes before it is planted in the soil. (Represented by treatment 4.)

(b) Mixing the seed with superphosphate for various periods before either broadcasting or sowing through the superphosphate box of the drill (represented by treatments 5, 6, and 7), or, with basic superphosphate (represented by treatments 8, 9 and 10).

With the exception of treatments 1 and 11, all seed was inoculated just prior to planting, or mixing with the fertilisers (the method of inoculation used being strictly according to departmental recommendations (1)) and the seed was perfectly dry when either mixed with fertiliser or sown. In all treatments where the inoculated seed was mixed with fertiliser before planting, the seed for each treatment row was mixed in every case with the full amount of fertiliser to be used in that row.

The seed for treatment 11 was inoculated 48 hours before being planted after all other treatments.

Treatments 1, 2, 3, 4, 5, and 8 were planted on 23/6/38; treatments 6 and 9 were planted 24 hours later, and treatments 7, 10, and 11 on 25/6/38, some 48 hours later.

All seed was covered with soil immediately after planting, the sowing depth being as near as possible to half an inch.

RESULTS.

The germination throughout was excellent and in spite of very careful observations, no differences in plant numbers could be detected in any particular treatments. Within a month of germination, however, the growth in treatments 1, 6, and 7 was obviously inferior to the remainder, and subsequently many of these plants, showing symptoms of nitrogen starvation as indicated by their reddish-yellow foliage and stunted habit of growth, died out.

By the end of August the harmful effect of mixing the inoculated seed with superphosphate prior to planting was seen to be related to the time of contact. Whereas the growth of treatment 4 was excellent, treatment 5 was somewhat inferior and the growth of treatments 6 and 7 appeared little better than treatment 1 in which the seed was not inoculated.

On the other hand, the growth of treatments 8, 9, and 10 in which the inoculated seed was mixed with basic superphosphate prior to planting, was striking by comparison; no differences could be observed and all were uniformly good.

On 7th September, 1938, this experiment was inspected by Dr. A. E. V. Richardson, Deputy Chief Executive Officer, C.S.I.R., Melbourne, Victoria, Professor J. E. Nichols, Professor of Agriculture in the University of Western Australia, and a number of officers from the Agricultural Department, W.A.

Without any knowledge of the randomised layout of the different treatments, Nos. 1, 6, and 7 were unerringly chosen as the most inferior in each of the six blocks. Opinions differed regarding the best treatment, as Nos. 3, 4, 8, 9, and 10 all appeared to be equally good.

During October a few plants in treatments 6 and 7 made better progress, being aided, it was thought, by a delayed inoculation, but it was quite evident that because of their very slow growth earlier in the season the amount of seed produced for regeneration by the plants in these treatments would be very limited.

Harvesting commenced on the 25th October, 1938, when flowering generally was completed, and each block was separately harvested by cutting the plants from each treatment at ground level and weighing the total produce of each half chain row.

In order to obtain some idea of the plant survival value of the different treatments, complete plant counts were also made.

Harvesting was completed on the 1st November, 1938, and after all the material had been thoroughly air dried (during which time plant counts were again checked), composite treatment samples were submitted to the Government Analyst for moisture and nitrogen determination.

DETAILED RESULTS.

TABLE 2.

Mean Yields per Treatment half-chain Row (Oven-dried Weights).
(Average of Six Randomised Replications).

Treatment No.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Actual Mean Yield (gms.)	40·7	161·7	278·3	300·5	217·3	80·8	73·3	355·7	332·7	332·2	213·7
Yield (%)	100	397	684	738	534	198	180	874	817	816	525

P> ·05—Diff. for significance = ±58·47 gms.
P> ·05—Diff. for significance = ±144%.

TABLE 3.

Nitrogen Percentages (expresseds on Oven-dried Samples) and Total Yields of Nitrogen per Treatment half-chain Row.

Treatment No.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Nitrogen (%)	2·2	2·01	1·97	1·93	2·15	2·22	2·19	2·13	2·28	2·18	2·02
Total Yield of Nitrogen (gms.)	·90	3·25	5·48	5·80	4·67	1·79	1·61	7·58	7·59	7·24	4·32
Total Yield of Nitrogen (%)	100	361	609	644	519	199	179	842	843	804	480

TABLE 4.

Mean Plant Numbers per Treatment half-chain Row.
(Average of Six Randomised Replications).

Treatment No.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Actual Mean Plant Numbers	174·3	216·0	245·3	223·2	229·3	188·5	161·8	240·6	231·2	235·2	252·0
Plant Numbers (%)	100	124	141	128	132	108	93	139	133	135	144

P> ·05—Diff. for significance = ±25·45.
P> ·05—Diff. for significance = ±15%

Discussion of Results.

By comparing the results of treatment 1 (*uninoculated seed*) with those of treatments 2 and 11 (*inoculated seed*) the effectiveness of the strain of rhizobial bacteria used can be established, for the sowing methods in these three treatments were similar.

The fact that the inoculated seed in treatment 11 was kept for 48 hours before planting does not invalidate this comparison, as the bacteria would not be expected to increase on the seed during this period, for the process involved the drying of the seed, by exposure to air, very quickly after inoculation, and furthermore, the mean yields of treatments 2 and 11 were significantly the same.

Reference to the tables of results will show that as a direct result of inoculation the mean yields and total nitrogen content of treatments 2 and 11 were increased approximately four and five times, and the plant survival figures were also significantly higher. The strain of rhizobial bacteria used was therefore highly effective.

Referring to the second object of the experiment, it will be seen from tables 2 and 3 that planting methods have considerably influenced the yield. *The best treatments for sowing inoculated seed in conjunction with superphosphate were those in which the seed and superphosphate were sown at the same time, but when no contact between them was made or the contact prior to planting was of very short duration.* Thus the mean yields of treatments 3 (representing the "small seeds" attachment) and 4 (representing the sowing of the seed and fertiliser through separate sides of the drill box) were significantly higher than the remaining sowing methods in which superphosphate was the fertiliser used. The total yield of nitrogen per treatment was also raised considerably by these methods of planting.

Where the superphosphate was separately applied 48 hours before planting (treatments 2 and 11) the yields were significantly lower than treatments 3 and 4, and significantly the same as treatment 5, in which the inoculated seed was in contact with the superphosphate for one hour prior to planting.

The yields of treatments 2 and 11 were lower than expected for it was not anticipated that the method of planting would exert any harmful effect directly on the bacteria.

Although the inoculated seed was planted in contact with the superphosphate (which had been applied 48 hours previously to the soil), the detrimental effect on the bacteria, would, it was thought, be no greater than in treatment 4 where contact between seed and superphosphate was momentary only, before planting.

In view of the soil type and its reaction, and especially as the soil had received heavy rain, and was moist in every case before the seed was planted, it seems more probable that the comparatively low yields obtained in treatments 2 and 11 were caused by the reversion of the applied phosphate to unavailable iron compounds in the soil; and as treatment 5 gave significantly the same yield, in spite of a considerable loss in effectiveness of the inoculation (compare the yield and total nitrogen of treatment 5 with 4) this explanation is further supported.

It is now well recognised that high levels of phosphate in the soil are important not only for plant growth but for the multiplication of the rhizobial bacteria, and hence in these treatments, if the applied phosphate was converted largely into unavailable compounds, plant development would be retarded by both lack of available phosphate and poorer nodulation due to the inability of the rhizobial bacteria to multiply in the soil.

The detrimental effect of mixing inoculated seed with superphosphate for periods of 1, 24 and 48 hours prior to planting, was strikingly illustrated in this

experiment. Significant reductions in yield were obtained for the first and second periods, whereas at the end of 48 hours, little further reduction resulted. The total yields of nitrogen and plant survival numbers were also lower in treatments 6 and 7 than in any other treatments in which the inoculated seed was sown in conjunction with superphosphate.

In order that these results should not be criticised on the grounds that reduction in yield had been brought about by the detrimental action of the superphosphate on the germination, rather than on the bacteria, a sample of subterranean clover seed retained from this experiment was tested for germination after being mixed with superphosphate (23 per cent. total phosphoric acid content) and basic superphosphate (17 per cent. total phosphoric acid content) for various periods (4).

The moisture content of the superphosphate (1.6 per cent.) and basic superphosphate (1.63 per cent.) used for germination study, was very similar to that used in this experiment, namely 1.84 per cent. and 1.3 per cent. respectively.

TABLE 5.

Germination of Sample of Subterranean Clover (Low Hard-seed content) after Mixing with Superphosphate and Basic Superphosphate for various periods.

Treatment.	Period of Treatment.	Germination (%).				Hard Seeds.
		10 days.	11-21 days.	Semi-hard.	Total.	
Superphosphate	4 hours	75	6	5	86	2
Do.	8 ,,	91	2	0	93	1
Do.	24 ,,	79	2	2	83	0
Do.	2 days	89	1	5	95	2
Do.	3 ,,	96	1	0	97	0
Do.	7 ,,	87	4	0	91	3
Do.	14 ,,	78	1	2	81	0
Control		82	4	3	89	3
Basic Superphosphate	4 hours	88	2	1	91	1
Do. do.	8 ,,	71	0	12	83	4
Do. do.	24 ,,	90	0	1	91	1
Do. do.	2 days	86	0	6	92	1
Do. do.	3 ,,	55	13	19	87	2
Do. do.	7 ,,	87	4	3	94	3
Do. do.	14 ,,	88	0	0	88	5

The germination test shows that mixing subterranean clover seed (of low hard seed content) with superphosphate and basic superphosphate of low moisture content for up to fourteen days did not materially affect the germination. A second test carried out with a sample of seed of high hard seed content gave similar results.

A further criticism that the bacteria present on the seed would, even if not mixed with fertiliser, normally lose their effectiveness for inoculation during similar periods of 1, 24 and 48 hours, can be disproved by comparing the yield of treatment 11 with treatment 2.

After inoculation the seed for treatment 2 was planted as soon as possible, whereas the seed for treatment 11 was held for 48 hours after inoculation before being planted by a similar method; yet the yield of each was significantly the same.

It is thus evident that the reduction in yield in treatments 5, 6 and 7 was solely brought about by the harmful action of the superphosphate on the bacteria as the result of mixing the inoculated seed with superphosphate for periods of 1, 24 and 48 hours prior to planting; but whether the superphosphate directly injures the bacteria by disinfection, or merely impairs them in some way for effective inoculation, is not yet definitely known.

Taking the difference in yield between treatment 4 and treatment 5 as a basis for calculating the loss of viable bacteria during 1 hour, a normal disinfection curve can be constructed, with numbers of bacteria regarded as the ordinates, plotted against the disinfection times as abscissas.

Such a curve is shown in Fig. 1 and it is of interest to note that the values for yield obtained in this experiment for treatments 6 and 7 where the inoculated seed had been exposed to the harmful action of superphosphate for 24 and 48 hours respectively, lie close to the theoretical curve. This strongly suggests that superphosphate when mixed with inoculated seed prior to planting kills the rhizo-

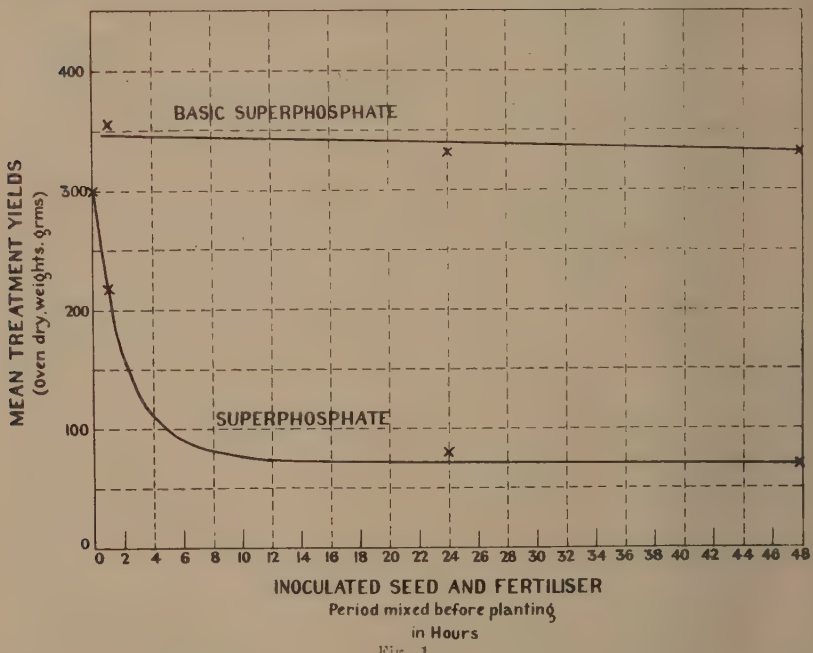


Fig. 1.

bial bacteria by disinfection, but a laboratory study by means of plate counts must be undertaken to prove that this is so. Plant survivals and total nitrogen per treatment were also reduced as a result of mixing the inoculated seed with superphosphate for 24 and 48 hours.

These results indicate in a very emphatic manner how easily the beneficial effects of inoculation may be nullified by mixing pure-culture treated seed with superphosphate prior to planting.

As compared with superphosphate, basic superphosphate does little damage to the bacteria, even after a period of contact for 48 *hours; for all the basic superphosphate treatments* (8, 9 *and* 10) *gave significantly the same yield* (*see Table* 2 *and Fig.* 1).

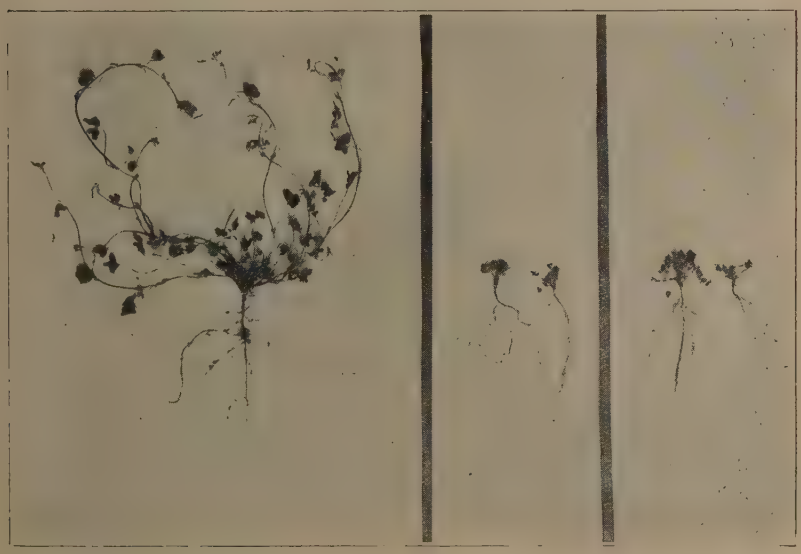
In spite of this however none of the basic superphosphate treatments were significantly higher than treatment 4, the best superphosphate treatment in which the inoculated seed was mixed with superphosphate and sown immediately, for the effective inoculation was not nullified by this momentary period of contact.

While harvesting was in progress numbers of plant roots were carefully examined for the occurrence and location of nodules.

As numerous workers have reported (5, 6, 7 and 8) that in general good strains of rhizobial bacteria produce large nodules located on the top portion of the root, while poorer strains produce many small nodules on the lateral rootlets, it is of interest to record that in this experiment where the same highly effective strain of bacteria was used to inoculate the seed, different types of nodules were produced by the plants in different treatments. The plants examined in treatment 10 (inoculated seed mixed with basic superphosphate for 48 hours before sowing) each possessed a few large nodules on the upper portions of their tap roots, while those in treatment 7 (inoculated seed mixed with superphosphate for a similar period prior to sowing), in which delayed inoculation had occurred in the late spring, possessed very small nodules on their lateral rootlets only, and on the roots of the uninoculated plants in treatment 1 nodules were almost entirely absent. (See plate 3.)

PLATE 3.

Variations in nodule size and placing produced by different treatments.



a. b. c.

(a) Plant from treatment 10 (inoculated seed mixed with basic superphosphate for 48 hours before planting), showing large nodules on upper portion of tap root.
(b) Plants grown from uninoculated seed (treatment 1), showing absence of nodules.
(c) Plants from treatment 7 (inoculated seed mixed with superphosphate for 48 hours before planting), showing small nodules confined to lateral roots.

In view of the general absence of nodules on the uninoculated plants, and the isolated nature of the site on which this experiment was conducted, it is unlikely that the plants in treatment 7 were inoculated after planting by rhizobial bacteria previously present in the soil, rather than by those introduced with the inoculated seed.

In this experiment it is thought, therefore, that *large nodules* on the upper portions of the tap roots of the plants in treatment 10 did not merely indicate the effectiveness of the strain of bacteria used, *but the early inoculation of these plants*

also, as a result of the introduction to the soil of large numbers of bacteria, which survived on the inoculated seed during this method of planting.

However, the possibility should be borne in mind, that the delayed inoculation of the plants in treatment 7 was brought about not only by the reduction in numbers of viable bacteria on the surface of the inoculated seed, but also by the harmful action of the superphosphate, which so injured the bacteria that physiologically they were converted into a less effective strain capable of producing nodules on the lateral roots only.

Recommendations for Sowing Subterranean Clover Seed to Ensure the Maximum Advantage from Seed Inoculation.

The results of this experiment indicate in a very striking manner the influence of sowing methods on effective plant inoculation.

A.—Wet Sowing.

1. *To ensure the maximum advantage from artificial seed inoculation the seed should not be mixed with superphosphate before planting, as superphosphate injures the bacteria.* With this object in view the best practical methods of sowing are those in which the inoculated seed is planted at the same time as the superphosphate fertiliser, but when no contact is made, or the contact between them is momentary only.

2. (a) Planting the inoculated seed by means of a special "small seeds" attachment to the ordinary grain and fertiliser drill, followed by light harrows; or (b) planting through separate sides of the drill box as, for example, when sowing with a light cover crop, are satisfactory methods. (In these or in any other methods the need for planting at the correct depth of ½ inch and no deeper than one inch should be borne in mind as experiments have shown that the germination may be adversely affected by too deep sowing (9). Also in districts of limited rainfall the cover crop may adversely affect the growth of the clover by competition for soil moisture.)

3. The application of superphosphate some time in advance of sowing the seed is unnecessary but if more convenient to the requirements of farm practice, it will yield fair results.

4. If for any reason the inoculated seed must be mixed with superphosphate, for either planting through the super box of the drill or for broadcasting, both inoculated seed and super should be dry, and it is strongly recommended that only a limited quantity be mixed at a time, so that the mixture can be sown within half an hour.

5. On ironstone soils where reversion is likely to occur, basic superphosphate offers possibilities, but whether (in view of its greater price and its lower total phosphoric acid content) it will prove more profitable than larger applications of superphosphate of the same monetary value is yet to be determined.

Where basic superphosphate is the fertiliser used the dry inoculated seed and fertiliser may be mixed together and the mixture should be sown within 12 hours.

B.—Dry Sowing.

The above recommendations are made for sowing under wet seedbed conditions as it is thought that any detrimental effect caused by contact between the inoculated seed and fertiliser when planting, would be further prolonged subsequently in dry soil.

6. For this reason when planting in dry soil is unavoidable, it is believed that the methods suggested in Recommendations 2 (a) or 3 will prove most suitable.

SUMMARY OF EXPERIMENT (1).

The inoculation of subterranean clover seed with an effective strain of rhizobial bacteria (*Rhizobium trifolii*) prior to planting, has materially increased the yield, total nitrogen content, and plant survival number. The methods of sowing inoculated subterranean clover seed, in conjunction with superphosphate (on new land under wet seedbed conditions), considerably influence the effective plant inoculation, and hence the yield.

Under these conditions the best practical methods of sowing are those in which the inoculated seed is planted at the same time as the superphosphate fertiliser but when no contact is made, or the contact between them is momentary only, and takes place just prior to seed and fertiliser reaching the moist soil.

Mixing inoculated subterranean clover seed with superphosphate (23 per cent. total phosphoric acid content) for periods of 1, 24 and 48 hours before planting is injurious to the bacteria, resulting in less effective plant inoculation, significant reduction in yield, and in plant survivals (for the two longest periods). Mixing inoculated seed with basic superphosphate (17 per cent. total phosphoric acid content), for similar periods before planting is not harmful to the bacteria as the yields remain significantly the same. Variations in both nodule size and placing were produced by mixing inoculated seed with superphosphate and basic superphosphate for periods of 48 hours before planting. These variations may either be related to the influence of these methods of planting on the numbers of viable bacteria introduced with the inoculated seed to the soil, or to a physiological change in the effectiveness of the strain of bacteria as a result of fertiliser injury, or to a combination of both of these factors.

As the result of this experiment, practical recommendations for sowing inoculated subterranean clover seed in conjunction with superphosphate and basic superphosphate are made.

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THE EFFECT OF INOCULATION ON THE GROWTH OF FIELD PEAS, LUCERNE, LUPINS, AND TICK BEANS.

Inoculation Experiments, 1938.

Experiment 2.

By reference to table 1 (Experiment 1) it will be seen that there is a considerable demand from farmers for bacterial cultures for the inoculation before planting, of Pea, Lucerne and Lupin seed, in addition to subterranean clover. The bacteria required for the inoculation of each of these legumes form distinct strains,

and thus the strain of rhizobial bacteria effective with peas is ineffective with lucerne, or lupin, and vice versa.

Each strain of the bacteria will serve to inoculate a group of closely related plants (cross inoculation group), but it is now well recognised that the inoculation obtained with all plant species in this group may vary considerably in effectiveness. For various reasons opportunities for the carrying out of Departmental experiments to demonstrate the advantages resulting from pure-culture seed-inoculation have in the past been limited, but many reports of excellent results received from farmers have left no doubt about this matter, where the instructions forwarded with the cultures have been carefully followed.

Objects of Experiment.

As some strains of rhizobial bacteria supplied by this Department have now been propagated continuously in pure culture for a number of years, it was considered advisable at this stage to test their effectiveness under field conditions by comparing the yields obtained from inoculated and uninoculated seed.

The strains chosen for test were those which have been in greatest demand, namely the pea, lucerne and lupin strains.

The varieties used in the experiment were the White Brunswick Field Pea, Bell Windsor Tick Bean, Hunter River Lucerne and W.A. Blue Lupin. Tick Beans are included in the group of plants which are considered to be effectively inoculated by the pea strain of bacteria and as (being immune to the pea weevil, *Bruchus Pisorum* (linn)) they have been increasingly planted for green manuring and other purposes, since this pest became widespread in W.A., further information concerning this point was desired.

The experiment was conducted at Ridge Hill (on a site adjoining that mentioned in Experiment 1), and at Forrest Field on the property of Mr. T. Maher, the layout in each case being identical.

The Forrest Field property is also situated in the Darling Ranges but some few miles from Ridge Hill, and details concerning rainfall, soil and vegetation are therefore similar to those described in Experiment 1.

Details of Experiment.

Each variety was sown in rows half a chain long and four links apart, alternate rows being planted with inoculated and uninoculated seed, and each treatment was replicated six times. Each row was hoed out to a depth of three inches and superphosphate at the rate of 1½ cwts. per acre was placed in the trenches so formed, some 48 hours before planting the seed.

The uninoculated seed of each variety was sown first in all the rows involved, followed immediately by the inoculated seed in all the remaining rows.

Seed for the inoculated rows was treated with a suspension of the appropriate bacteria in skim milk, before planting in accordance with Departmental recommendations (1).

The rates of sowing were lucerne 10 lbs. per acre, tick beans, peas and lupins 132 seeds per ½ chain row. At Forrest Field the planting was carried out on the 3rd and 4th June, and at Ridge Hill, on the 22nd and 24th June, 1938.

The depth of planting was approximately ¾-inch for the lucerne and 2-inch for the remaining legumes.

At both places the germination of the lucerne, peas and tick beans was excellent and no difference in favour of either the inoculated or control rows could be noted. By comparison the germination of the lupins was extremely uneven throughout. Within a month of planting, the inoculated rows of peas and lucerne showed a marked superiority in growth over the controls and in colour they were a deeper green.

PLATE 4.

Inoculated and Uninoculated Lucerne grown at Forrest Field.

Fig. 2.

Fig. 3

Fig. 2.—Plants in foreground grown from uninoculated seed. Plants in second row grown from inoculated seed.

Fig. 3.—Plants in centre row grown from uninoculated seed. Plants in alternate rows grown from inoculated seed

The increase in the green yield in favour of inoculation amounted to 117 per cent

At the Forrest Field site this difference in the growth of the inoculated peas became less marked as time went on, due apparently to the delayed inoculation of the controls with bacteria present in the soil.

At no stage during the experiment could any difference be detected between the inoculated and control rows of tick beans and lupins.

In view of the late planting, the lupins made quite satisfactory growth, but with the exception of a few plants in either treatment the tick beans were stunted.

The marked superiority of the inoculated rows of lucerne at both sites, and of the peas at Ridge Hill, was maintained throughout the experiment.

Harvesting was carried out on the following dates when the lucerne was in flower and the majority of the pods of lupins, peas and tick beans contained half grown seed.

	Forrest Field.	Ridge Hill.
Peas	9/9/38	26/9/38
Lucerne	10/11/38	10/11/38
Lupin	10/11/38	10/11/38
Tick Beans	10/11/38	

The tick beans at Ridge Hill were not harvested owing to the poor growth they had made.

Discussion of Results. (See Table 6, page 78.)

Although both sites were cleared of native vegetation shortly before the experiment commenced the soil at Forrest Field could not be considered truly virgin as regards its content of rhizobial bacteria necessary for the inoculation of the common agricultural legumes. As it was situated only a few yards from the boundary of an orchard in which inoculated legumes had previously been grown, and at a lower level, it was subject to considerable bacterial contamination by rain-washed and wind-blown soil.

Despite this fact *the increase in the green yield of lucerne in favour of inoculation was considerable, amounting to* 117 *per cent.* (see Plate 4, Figs. 2 and 3) and 49 per cent. in the case of peas. At Ridge Hill, on the other hand, except for rhizobial bacteria specific for native species of plants, which appear to be ineffective for the nodulation of agricultural legumes, the soil in this respect was thought to be completely sterile. At this place the contrast between the inoculated and uninoculated rows of peas and lucerne was very marked, *the uninoculated peas being a complete failure, whereas the inoculated plants which were sturdy and healthy, yielded more than eleven times the green weights of the controls* (see Plate 5, Figs. 4 and 5), while *the inoculated lucerne yielded nearly four times the weight of the controls.*

At neither site were significant increases in yield obtained by artificial inoculation of the lupin seed, but this was almost certainly due to the inoculation of the controls with bacteria, either in the soil adhering to the seed (with which they were heavily coated) or in the soil in which they were planted, rather than to the use of an ineffective strain. A careful examination of the roots of plants taken from *both* the *inoculated* and *control rows* showed that all carried the bacterial nodules on their tap roots.

The tick beans, even after allowing for the late planting, made disappointing growth at both situations, and the majority of the roots of plants taken from both inoculated and uninoculated rows showed no evidence of nodulation.

As reported elsewhere (2) the pea strain of rhizobial bacteria used in this experiment for the inoculation of tick beans does not appear to be equally effective with all plant species of the cross inoculation group, and it is apparent, therefore, that a new strain must be procured for the successful inoculation of this legume.

PLATE 5

Inoculated and Uninoculated Field Peas grown at Ridge Hill

Fig. 4.

Fig. 5.

Fig. 4.—Plants in foreground grown from uninoculated seed. Plants in second row grown from inoculated seed.

Fig. 5.—Plants in centre row grown from inoculated seed. Plants in alternate rows grown from uninoculated seed.

The increase in the green yield in favour of inoculation amounted to 1,021 per cent.

TABLE 6.

Legume.	Forrest Field.				Ridge Hill.			
	Green Yields (Total of 6 half-chain rows).		Green Yields (Percentage).	Nitrogen (Percentage on Dry Basis).	Green Yields (Total of 6 half-chain rows).		Green Yields (Percentage).	Nitrogen (Percentage on Dry Basis).
	Uninoculated.	Inoculated.			Uninoculated.	Inoculated.		
	lbs. ozs.	lbs. ozs.			lbs. ozs.	lbs. ozs.		
Field Pea	23 4½	...	100	2·24	4 3½	...	100	2·25
	...	33 15½	149	2·88	...	47 4¾	1121	2·96
Lucerne	4 1	...	100	2·02	2 4¼	...	100	1·89
	...	8 13	217	2·52	...	8 10½	382	2·30
Lupin	27 9¼	...	100	...	21 8½	...	100	1·89
	...	27 15	101	...	...	22 4¼	103	3·83
Tick Bean	16 6¼	...	100	2·17	Not harvested owing to unsatisfactory growth.			
	...	16 11¼	102	2·12				

For this reason isolations from nodules obtained from healthy tick bean plants will be made in the Plant Pathological Laboratory and it is hoped that the new strain will be available for testing during the forthcoming planting season.

Although the percentage differences in nitrogen content in favour of inoculation were in general not very marked yet, taking into account the extra green weight produced where effective nodulation was secured, the increase in the total yield of nitrogen was considerable.

SUMMARY AND CONCLUSIONS (EXPERIMENT 2).

An experiment to test the effectiveness of the pea, lucerne and lupin strains of rhizobial bacteria is described.

Large increases in the yield of peas and lucerne have been obtained by artificial seed inoculation with the requisite strains of rhizobial bacteria.

In soil where the requisite bacteria do not already exist, artificial inoculation of these legumes, will (provided other growth factors are satisfactory) make all the difference between success or failure of the resulting crop, as the bacteria are apparently carried to only a very limited extent on the seed itself by natural means.

In soil where the bacteria are to some extent already present, less spectacular differences in yield may be expected, nevertheless it is considered that here also artificial seed inoculation of peas and lucerne is still warranted. Although no significant increase in the green yields of lupins was obtained by artificial seed inoculation it is confidently believed that this was due to accidental inoculation of the controls with bacteria present in the soil adhering to the seed, rather than to the use of a defective strain.

For the inoculation of tick beans the pea strain of rhizobial bacteria is ineffective and a strain specific to this legume will be procured for this purpose.

ACKNOWLEDGMENTS.

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THE FEEDING OF POULTRY ON WHEAT AND OTHER GRAINS.

"Fowls Cannot Lay on Wheat Alone."

In a previous article we discussed the feeding of poultry by utilising the feeds most commonly used, not only by the commercial poultry farmer, but also by those farmers who were able to procure bran and pollard at reasonable rates. It is evident that, in some districts, the farmer has had perforce to use the product of the farm, and, in most cases, although he has a supply of bran and pollard when he sends grain to the mills for milling into flour for his own use, the supply is restricted, and is in some cases negligible for practical purposes. In other cases it is well nigh impossible to obtain even the means of grinding the grain, and the farmer imports his flour requirements.

In both instances the farmer is bound to use a diet which is based on the grain in its many forms—whole, gristed, boiled, or soaked. It is for these farmers that this article is written.

We have heard of the several ways of using the grain. Some methods are open to question, while others are admirable. When we are to discuss the feeding of poultry, we must understand the principles of feeding and the feeds used. We have proteins, we have carbohydrates, we have fibre, minerals and also vitamins. All are wanted and all must be so incorporated in the rations that the birds will neither be starved nor restricted in the supply of any particular form of food, or, put in another way, they will be obtaining the correct balance of all requirements. Any shortage of one or the other will show up in the egg production of the layers, the poor growth of the birds which are to be kept for flesh production, and also in the tendency of all the flock to be weakened in constitution.

Briefly speaking, all foods must contain the following constituents:—

Proteins—those parts of the food which are used by the bird to make body, eggs and feathers.

Carbohydrates—those portions of the food which provide the driving force which assists the birds to convert the proteins into body, eggs and feathers.

Fibre—the portions which provide the bulk and aid digestion.

Vitamins—complicated elements necessary to growth.

Minerals—for the bone, body and egg formation.

Moisture—a necessary adjunct to all matter.

Roughly, the above are the necessary ingredients of all poultry feeds and all must be present in the ration in the right proportions.

When we are considering the feeding on the farms we will have—

Bran in restricted quantities;

Pollard, also in restricted amounts;

Cereals such as wheat, oats and in some cases, barley;

Animal foods such as the rabbit, the sheep, the kangaroo, and the milk, either skimmed or separated.

The feeding values of foodstuffs is determined by the percentage of the various components, such as—

Proteins

Carbohydrates

Fats and oils

Minerals

Fibre and moisture.

Protein is a nitrogen-containing food element used for flesh-forming, the building up of waste tissue, and most essential for egg production.

Carbohydrates are made up largely of starch, sugars, gums, etc., which produce heat and energy and form body fats.

Ash is the residue of burnt up foods and contains the minerals necessary for development of bone and feathers, and the formation of egg shell.

Fibre is the outer cells of grains and the fibrous matter in plants, and is not digestible; but a percentage is always present and is necessary to assist digestion.

Moisture in varying proportions is found in all foodstuffs.

Protein is the most expensive ingredient of any feed. It will produce heat and energy, but as a source of heat and energy is too expensive. We therefore concentrate on other ingredients high in carbohydrates and fats when we desire our energy-forming foods. Let us examine the foods for protein and carbohydrates.

Wheat and oats contain approximately 1 part protein, 7 parts carbohydrate, 12 per cent. moisture.

Bran and barley contain approximately 1 part protein, 5 parts carbohydrate, 8 per cent. moisture.

Pollard contains approximately 1 part protein, 6 parts carbohydrate, 9 per cent. moisture.

Skimmed and separated milk contain 1 part protein, 2 parts carbohydrate, 88 per cent. moisture.

Dried Butter Milk contains approximately 2 parts protein, 3 parts carbohydrate, 9 per cent. moisture.

Meatmeal contains approximately 2 parts protein, 1 part carbohydrate, 9 per cent. moisture.

Fresh meat contains approximately 1 part protein, 1½ parts carbohydrate, 67 per cent. moisture.

In order to have a balanced ration, we are expected to arrange the proportions of the feeds so that the ratio between the proteins and the carbohydrates is at 1 to 4.5 or 1 to 5. These figures are used only as a guide, but they are near enough for our purpose.

It will be noticed that in no case are the foods balanced in such a way that they could be efficiently fed to poultry unless mixed with some other ingredients. Therefore we are forced to ascertain the correct amounts of each and every ingredient incorporated so that we are able to obtain the correct balance of 1 to 4.5 or 1 to 5.

If the ration is so constituted that it contains one part protein to less than 4.5 carbohydrates, the ration is said to be "narrow."

If the proportion is greater than one part of protein to five parts of carbohydrates the ration is said to be "wide."

It will be noticed that wheat is "wide," but bran is nevertheless nearly balanced. However, bran is useless when fed alone owing to its bulky nature; yet it is very valuable when used as an essential ingredient, giving a vegetable protein. Pollard is "wide," milk is "narrow," and the meatmeal exceptionally so. Hence we balance the rations of wheat, bran, pollard, etc., and adding the highly concentrated protein foods (milk and meatmeal) in such a way as to ensure palatability and nutriment sufficient for growth, repair of waste tissues, energy and eggs.

When considering any ration we must concentrate on the dry ingredient basis for all calculations. Moisture is not feed in the true sense. Water is essential, but we must never consider it when talking of feed and feeding values.

Wheat Feeding.—It is the practice of some farmers to feed the birds on wheat alone, giving the grain both morning and evening. At times the rabbits and milk are incorporated in the ration.

When one feeds wheat solely either as whole, soaked, boiled or gristed, the ration is known as "wide," that is, the ratio is greater than the 1 to 4.5 or 5 and the wide ration will make the birds fat. On the other hand, if the food were to be made up solely from meatmeal, the ration would be "narrow" and the birds would quickly fade away, but the correct amounts of two feeds incorporated in the mash will give you the desired balance. It will then be readily understood that the farmer will in every case find it necessary to purchase the meatmeal.

Certainly use all the native animal food possible, but the high moisture content of those meats will not allow of sufficient protein in the ration to balance the ration.

Amount of Food Necessary.—The average ration for a bird is 4 oz. per day of dry matter.

When analysing that statement of 4 oz., it must be understood that it also means an average producer and, as the average production is around 130 eggs, and as "you put into the bird what you want, etc," how can a producer of 230 eggs lay that number if you only give her an average ration?

A four-gallon kerosene tin will hold about 50 to 60 ration of wet mash for your stock. One can assume that the birds are intelligent enough to know that they can get no more until the grain feed in the afternoon and so they eat all they can, both the small producer and the high producer. The small producer cannot use all the egg-forming ration to advantage, so it is lost. The large producer does not get enough. Now place in front of the same birds a dry mash hopper and study the trap nests. It will be found first of all that the kerosene tin will feed 100 rations in the morning and all will be content. When registering the trap nests and watching the birds when released, you find the solution to feeding the high producer.

When released from the trap nest, the high producer rushes (no other word for it) to the hopper, while the low producer casually goes outside the shed, finds a convenient hole and settles down, which proves that the high producer must get more feed than the low producer, and that a kerosene tin to 100 is sufficient feed for a low producer.

When feeding at night all will leave the hopper to partake of the grain.

Four ozs. of dry matter also means 2 ozs. of a mixture of bran, pollard, or of wheatmeal, meatmeal, oilcakes, bonemeal at morning and 2 ozs. of wheat at evening.

Measure out 2 ozs. of mash mixture and place it in a well-developed crop and see how little space is occupied. The crop is about half full and anything

half full is hungry, and as a hungry bird is not contented, fill it up with a bulk (green feed), which, besides filling the crop, aids digestion.

Weigh out 2 ozs. of wheat and the same thing occurs—the bird would go to bed hungry. Therefore, fill the crop with green feed fed after the wheat. Besides filling the crop, it again aids digestion. Do not feed more than 2 ozs. wheat with that 2 ozs. mash.

The feeding must be studied in a careful manner. We may certainly give the birds "as much as they will clean up in 20 minutes" and we hand out the wheat as if it does not cost anything.

Wheat Feeding.—It is easily seen that the fowls must have food before them at all times. And the feeding with wheat alone as a grain presents its problems to the farmer. Wheat may be fed as whole grain, soaked grain, and boiled grain.

Whole Grain.—This practice of feeding whole grain at all times should be discouraged. It is a method which does not assist in obtaining the best from the fowls. If the bird is forced to eat whole grain at every meal, the monotony of the diet will affect the quantity eaten by the stock and any restriction in this direction will affect the laying, and also adversely affect the constitution.

It is also difficult in incorporating with the protein requirements, and then the birds will be sure to eat more wheat in proportion to the protein concentrates than is necessary. The feeding of the correct amount of greens will also be well nigh impossible. All wheat feeding is therefore discouraged.

Gristed Wheat.—This form of feeding wheat for incorporation in the morning mash is in direct contrast to whole wheat feeding. It is about the best way of feeding the wheat in the mash. The gristed wheat will "mix" well with the greens and the other ingredients. It will "take" the meatmeal and the bone meal. It provides the base for a palatable mash. It also allows of convenient dry mash feeding. And there are very few farms which are without a grain crusher.

Soaked wheat is for those who are handicapped because of the impossibility of obtaining the gristed wheat, the bran, or the pollard. Soaked wheat provides one of the best methods of providing not only a balanced mash, but also a palatable one. But a word of warning must here be given: Soaked grain swells and it must not be considered that the water incorporated in the swollen grain is a substitute for food. Grain will increase to nearly double its size when soaked, but it will not provide food for double the number of layers.

Boiled Grain.—Boiled grain is extensively used in the farming districts, and this also is an excellent method of providing a base for balanced ration which is also palatable.

Oats and Barley.—These two grains can be fed with success if used in a similar manner to wheat feeding, the only difference being the large proportion of fibre. The extra percentage of fibre must be compensated by giving a larger measure (by weight).

The same principles of feeding are to be applied when one is using grain feeding as one uses when applying pollard and bran and wheatmeal feeding. Balance the ration feed sufficiently and see that the ration is palatable.

FEEDING.

Gristed Wheat.—Gristed wheat without either bran or pollard is fed in the same manner as one would feed if the other foods were available. One must realise that the wheat alone is wider than when mixed with bran, or bran and pollard.

The protein meals to be added will therefore have to be in greater amounts; but this will not materially increase the cost of the ration. The fowl can only consume a certain amount, whether it be all wheat, all meat, or a mixture of both.

Mix the gristed wheat with the chaffed up greens and meat meal and moisten with either the skimmed or separated milk or water. The mash should be crumbly and not wet nor sloppy.

The dry mash for the all-day feeding will be mixed with the same proportions as given for the morning mash. Feed whole grain or even soaked grain for an evening feed.

Use a ration as follows:—

Morning Mash (for all breeds)—Greens, 10 parts by measure; gristed wheat, 5 parts by measure; meat meal, ⅝ part by measure; bone meal, ¼ part by measure.

Dry Mash (Whites)—Gristed wheat, 5 parts by measure; meat meal, ⅝ part by measure; bone meal, ¼ part by measure.

Dry Mash (Australs)—Gristed wheat, 5 parts by measure; meat meal, ¾ part by measure; bone meal, ¼ part by measure.

Wheat at Evening Meal—Dry: 1½ oz. per bird. Soaked: 1½ oz. (dry weight) per bird; or "by measure" use a 1½ lb. golden syrup or treacle tin to every 15 fowls for dry wheat or to every eight fowls when soaked.

Soaked Wheat Feeding.—The wheat is soaked for 24 hours and then fed to the birds. The methods used are to place the soaked wheat in a trough and mix with the required amount of meat meal and bone meal and this is then fed in troughs to the birds. Do not throw on the ground. Another practice is to make a soup of the meatmeal and soak the grain in the soup.

The portions of wheat to meatmeal is the same as given for gristed grain.

Unless the farmer uses gristed wheat for a dry mash the birds must be fed three times a day so that the farmer is assured they are obtaining all they desire. Care must be taken to see that the meatmeal is carefully regulated.

Boiled Wheat Feeding.—The wheat is boiled and the meatmeal and bone meal are incorporated. The resultant mash is rather sloppy and care must be taken to see that the food does not ferment if left long in the troughs. Again three meals must be given, unless of course, the farmer also grinds grain for a dry mash.

The Feeding of Fresh Meat.—On the farms there is evidence of obtaining fresh meat in some form or other, and one should not neglect to make use of "home grown" product. Rabbits, sheep, calves, kangaroos, all have their place in the ration. One must understand, however, that these sources of food are very high in moisture and therefore allowance must be made for this bulky ingredient.

It has been ascertained that the fowl requires about 1⅜ oz. of lean fresh meat per day in order to meet its requirements in protein. Apart from the cost, the size of that amount of fresh meat will fill the crop and the bird would not be able to obtain sufficient of the other foods necessary for body and egg production. By all means use the fresh meat available, but realise that it is even then necessary to add meatmeal to the ration. The fresh meat available will allow of a small reduction in the amount of meatmeal to be used and therefore reduce the cost of the rations; but meatmeal cannot be eliminated altogether.

Skimmed or Separated Milk.—These two forms of milk are generally available in more or less amounts on any farm, and they should be used in the feeding of the fowls. Again one must remember that these two forms are so much water with a little hard food minerals added. A good gauge is to consider one gallon of milk as equal to one pound of dry milk powders.

Dry Milk Powders.—As dry milk powders are an advantage when feeding poultry, it might not be out of place to mention them in relation to the feeding on the farms in the wheat areas.

The dry powders are the product of the butter factories and are excellent sources of protein. The usual method of feeding dry milk is to reduce the meat-meal by half and add an equal measure of the milk powder, and then ascertain the correct proportion of the meatmeal by watching the colour of the droppings.

But when using the skimmed or separated form, give to the birds all they can consume. Mix the mash with milk, soak the wheat in it or boil the wheat in it.

When the farmer appreciates that the protein is the material which is so essential to the growth of body and eggs and feathers and that the carbohydrates are the energy-forming foods which allow the body to turn the protein into those three factors, it will be evident that there is a definite control over the rations. The proteins cannot be used unless there is something to provide the motive power. Carbohydrates provide that power. If the carbohydrates are not being used to a maximum capacity, the bird has a power of converting the surplus carbohydrates into a reserve and the reserve takes the form of layers of fat. When fat is present the bird has a great reserve at hand to meet any emergency. But that reserve of fat is the tell-tale to the farmer that he is not balancing the rations properly.

Any reserve of fat built up is a definite sign that the bird is not receiving sufficient proteins in the rations. Put another way, the machine has not been supplied with sufficient raw material and is therefore not doing work. It is idling. Supply more proteins and the carbohydrates will have more work to do; more body (to a certain degree) or more eggs will result, and when the bird is in the moult, the feathers will grow quicker. If the correct proteins have been supplied, the carbohydrates will all be used in converting the proteins into the correct channels. And, on the other hand, if too great a proportion of protein is supplied, the machine will be overloaded (as it were) and will run hot. The bird will become run down. Blood spots will form in the eggs. The body will be weakened and eventually a prolapse will occur.

You therefore have a definite tell-tale as to the balance of the rations, and as in all cases it is necessary for the birds to carry condition, it will be evident that the birds should always carry a small layer of fat. This is a reserve to meet any emergency such as cold snaps, etc. The feeding is therefore controlled to obtain the maximum results, whether it be for body, eggs or quick growth of feathers, and a correct amount of fats to meet the emergencies.

It has been previously mentioned that a fairly definite guide to the balance of the rations is the colour of the droppings under the perches. The colours of the droppings can vary from light yellow to dark brown, to black, then to a slight reddish tinge. Be careful you are not confusing the colours if you are using charcoal or the soil is of a reddish nature. We must compensate for this, as the birds will consume the charcoal and soil and that will pass through, causing a false colour.

If it is yellow we have too much carbohydrates and fats to protein—the ration is "too wide."

If it is brown this means the same—"too wide."

If it is black-brown we have a ration as near as desired.

If it is black we are near the danger zone.

If it is red bloodish colour the ration is "too narrow," and dangerous.

Aim for the black-brown colour—and satisfaction. Do not consider the white tips—these are urine and are of no importance to our discussion. Simply this—if light brown, too much wheat to meat; if black-brown, correct; if reddish, too much meat to wheat. Remedy by varying the meatmeal. It is the highly concentrated protein ingredient and it can influence the ration quickly.

When gauging colour, take a quick glance for colour effect, not an isolated concentration.

This sign will give you a base on which to work, but as one cannot define the close shades of black-brown, it is necessary to handle the bird for a check and note the condition. If the colour of the droppings is black-brown and the bird is putting on fat, it is evident that the colour is not of the correct shade. Furthermore, it is not possible to gauge the correct shade, so resort must be made to handling. If the fat layer is increasing, a small addition to the percentage of meatmeal will reduce the fat, but to all intents and purposes the colour change may not be evident. But that doesn't mean that there has been no change. You can therefore be sure that if the fat is too great you are to add more meatmeal and keep at the extra amount until a reduction is noticed. On the other hand, too high a percentage will be noticed by the reddish colour in the droppings and also in the poor, lean condition of the flesh. The flesh will appear to be of a jelly-like substance and not having that firm feel which is noticeable when the birds are in good condition and carrying a little fat.

It will be realised also that the percentages of protein must vary according to the season. In the winter the energy-forming foods which supply the source of heat will be assisting to keep the bird warm. They will have two works to perform—producing eggs or feathers and supplying warmth. The proteins, therefore, must be lower in proportion; whereas in the summer no energy-forming food is required for keeping the bird warm, and therefore the proteins must be in greater proportion than in winter. This is evident by the colour of the droppings.

If one standard ration is used throughout the year, it will be found that the birds will be thin in the winter and then place on fat in the summer. It is generally the fat birds which die in the heat waves. The practice, therefore, is to so fluctuate the rations so as to meet the seasonal conditions.

Further, as the proteins are used to make eggs, a change in the percentage of this ingredient is necessary during certain periods of the year. In the winter the birds will be requiring less protein for egg production than they will when the production rises to the peak in the spring, and as the reduction in the egg production takes place in the summer the protein used for egg production will be less.

When the autumn approaches the birds will be ceasing their production, as they will be preparing for the annual moult, and as winter is approaching they will require a reserve of fat to meet the cold blasts of the winter season The percentage of protein is therefore reduced because of the two factors reduction in the lay and the approach of winter. When the feathers are growing, the birds will need an addition of protein again. All these alterations are appearing complicated, but the signs are simple and definite. The condition of the bird is the real one and only guide, and by using more or less meatmeal in the rations, one will be able to alter the percentage of proteins from day to day if necessary. A little fat in the winter, none in the summer, and as the winter approaches again, a slight addition. When the birds are moulting you will be able to correct the

rations if you watch the condition of the bird. Any tendency to placing on thick layers of fat will tell you immediately that the bird is not receiving sufficient meatmeal from which to make the quick growth of feathers.

Fat Requirements.—When the pullets are beginning to lay, it will be noticed that there is very little fat between the pelvic bones and the breast bone, but as the winter approaches this layer should be about 5/8in. thick for the light breeds and about 7/8in. for the heavy breeds. When the spring approaches the birds are laying many more eggs and this layer must be reduced so that the thickness in the summer should be about 3/8in. for the light and about 1/2in. for the heavy breeds.

If for any reason the birds are not fed sufficient protein, it will be noticed that the fat grows thicker and this is the sign that the rations are not balanced. On the other hand, should the fat disappear or be less than the amounts suggested above, the manager should reduce the meatmeal immediately.

All fluctuations are done gradually. It would be dangerous to keep the meatmeal at a double quantity for any length of time, but double meatmeal for two or three days would not injure the birds if they were carrying fat. And again, the reduction of the meatmeal by half for any lengthy period would be quickly noticed by an immediate reduction of production.

Our Australorps are condemned as layers for more than one year, and all because the feeding is at fault. The birds have been allowed to get fat when in the moult. They must have a rest from laying, but if the meatmeal is withdrawn from the rations during this moulting period it will immediately show up. The bird will get fat and the time taken to grow the feathers will be prolonged.

The moulting bird must have meatmeal in order to produce a quick growth of feathers.

The wheat farmer and those who are feeding wheat have no problems which cannot be solved as easily as those arising when feeding bran and pollard.

Green Feeds.—It has been the practice to impress upon the farmer that greens of some sort are necessary to the well-being of the fowls. But in some districts it is well nigh impossible to procure green feed. In those districts it is necessary to resort to substitutes. And there are several.

Sprouted grains are the most popular means of supplying the greens, but other substitutes can be used. One can use chaff—either lucerne, wheaten or oaten.

Sprouted Grains.—Sprouted grain is one of the simplest means of obtaining the green feed requirements of the flock. The grain is soaked for 24 hours and then spread out either in troughs, on bags, or in trenches in the ground. Each day a further amount is soaked and spread and after seven days the resultant growth is used for feeding in the wet mash in the morning and after the wheat in the evening. The average growth after seven days is about four inches. This method will assist the feeding and at the same time will provide the requisite amount of necessary vitamins. The troughs are made with wood bottoms and have a side board. The grain, after soaking, is spread over the trough to a thickness of one inch. Every day the grain is sprinkled with water to keep a continued growth. To feed in the mash, cut off the young shoots and cut fine. For the evening feed the tender roots are cut into portions and eaten by the fowls with relish.

When using bags on which to spread the soaked grain it is advisable to cover with a top bag, keeping the top bag wet for two days, after which it must be removed. Daily watering is then necessary.

The most popular method of sprouting grain when water is a serious consideration is to place the soaked grain in a shallow trench in the soil in a shady portion of the farm. If necessary, build a bough shed for covering. A trench is made by using a shovel. Make the trench shovel width and about two inches deep. The length depends on the amount required for the daily feed. After soaking for 24 hours, the grain is spread in the trench to a depth of one inch and is then covered with a layer of soil about ¼ inch deep. There is sufficient moisture in the soaked grain to keep continual growth for the seven days or even longer.

When wanted for use, the shovel is run under the roots and the trench can then be used for a further supply.

In all cases the amounts necessary for the day's feeding can be easily ascertained.

The above three means of obtaining greens are within the reach of every farmer and therefore the birds will be all the better if fed the necessary daily amount.

Chaffed Hays.—If one prefers to use substitutes for green feeds, one can resort to the use of chaff. Lucerne chaff is one of the most popular feeds. The cost is small and all that is necessary is to soak the chaff overnight in hot water. Nevertheless, the farmer has his own supply and there should be no need for him to purchase lucerne chaff. When cutting the wheaten or oaten hay for his stock the supply is immediately available for the fowls.

But the hay must be cut green. Any tendency to dry yellow straw and a little grain in the heads is unsatisfactory. When cutting the hay, the grain should be soft and the whole of the plant should be in a green condition. When made into hay and chaffed the resultant feed is easily steamed when wanted and fulfills the objective of supplying the bulk of the vitamins. Chaffed hay, whether lucerne, oaten or wheaten, is an excellent substitute for green feed, but it is not as palatable as the succulent green feed. Nevertheless, for those who are without the means of obtaining greens the use of either one of these chaffs will meet all requirements.

The steamed chaff can be used in the wet mash in the morning, the dry chaff can be added to the dry mash, and the grain can be soaked for an evening feed. Or the chaff can be used in the mash, and for an evening meal the sprouted grain can be given after the hard grain.

With the feeds available, together with the means of obtaining green feed, or the substitute of soaked chaff, the farmer in the dry wheat areas will be well served with all the essential foods required. There is no reason why the egg production and condition of the flock should not be all that is desired.

If the principles of feeding are kept uppermost in the minds of the manager, it is easy for all the foods mentioned to be used in varying forms. It is also easy to so arrange the organisation of feeding to be a pleasure rather than a drudgery. The birds will want a well-balanced ration, a supply of green feed or its substitute, and the various minerals which assist to keep the birds in good health and high production.

The minerals are to be found in the feeds supplied. All that is then necessary is to augment the minerals with the shell grit for egg shell formation, the hard grit for assisting the bird to grind its food, and fine charcoal to keep the digestive organs in clean condition.

THE VALVE POTENTIOMETER AND ITS APPLICATION TO pH DETERMINATION.

By H. H. Kretchmar, B.Sc., A.A.C.I.

FOREWORD.

Those readers interested in valve potentiometers will know that a large amount of data has been published in this connection, but, as it is scattered throughout many journals, some not easily accessible, the writer has considered it advisable to collect together all such data as is relevant to the design and use of a potentiometer for pH determinations.

For the benefit of those chemists not acquainted with the theory of the modern valve, a short introductory section on this subject has also been included. The theory of the grid circuit has been reconsidered and the effect of the valve internal grid-filament impedance taken into account. Also a section has been added which enables one to calculate the optimum value of external valve anode resistances (an important factor in the design), which, it is believed, has not previously been considered.

INTRODUCTION.

The following very brief notes may serve as an introduction to the action of the valve.

The thermionic valve consists of an exhausted envelope, generally made of glass, containing a number of metal elements known as electrodes. One of these electrodes, the cathode, is a source of electrons. It may be directly heated by the passage of an electrical current—the filament current—or indirectly heated by a special heater element which is itself heated by an electrical current. The emissivity of the cathode may be, and generally is, in the modern valve, increased very greatly by coating it with thorium or with a layer of one of the alkaline earth oxides such as barium oxide. The indirectly heated cathode has advantages over the directly heated filament type. Such advantages are an equipotential surface and comparative freedom from heating current variations, so that alternating current may be used.

The simplest thermionic valve contains, as well as the cathode, a second electrode known as the anode or plate. If the anode be connected to the cathode through a milliammeter a positive current will be indicated flowing from the cathode to the anode in the external circuit. This is due to the electron stream flowing from the cathode to the anode within the valve. Since the current is due to a unidirectional electron flow, the device is a rectifier. All the electrons emitted by the cathode do not reach the anode and there is an accumulation of them in the inter-electrode space giving rise to the "space charge." If the anode is given a positive potential with respect to the cathode more electrons are attracted to the anode or plate and the anode or plate current increases. With increasing positive potential on the anode the anode current increases until all the electrons emitted by the cathode are being collected by the plate: further increase of anode potential causes no further increase of anode current for that particular cathode temperature and this maximum anode current is known as the "saturation current" for the particular filament temperature being used.

In the three-electrode valve a further electrode, known as the grid, is added. This usually takes the form of a mesh or coiled wire grid and is almost invariably placed between the cathode and the anode. When given a negative potential with respect to the cathode it acts as a partial barrier to the flow of electrons from the cathode to the anode, its effectiveness in this respect depending upon the magnitude of the negative potential applied to it.

If now the anode current for such a three-electrode valve be determined for various values of anode and grid voltage, the results may be plotted to give a graph of the following form (see Fig. 1). Each curve corresponds to a fixed anode voltage. Generally, the upper flat portion of the curves corresponding to the saturation current will not fall within the working range of a modern valve.

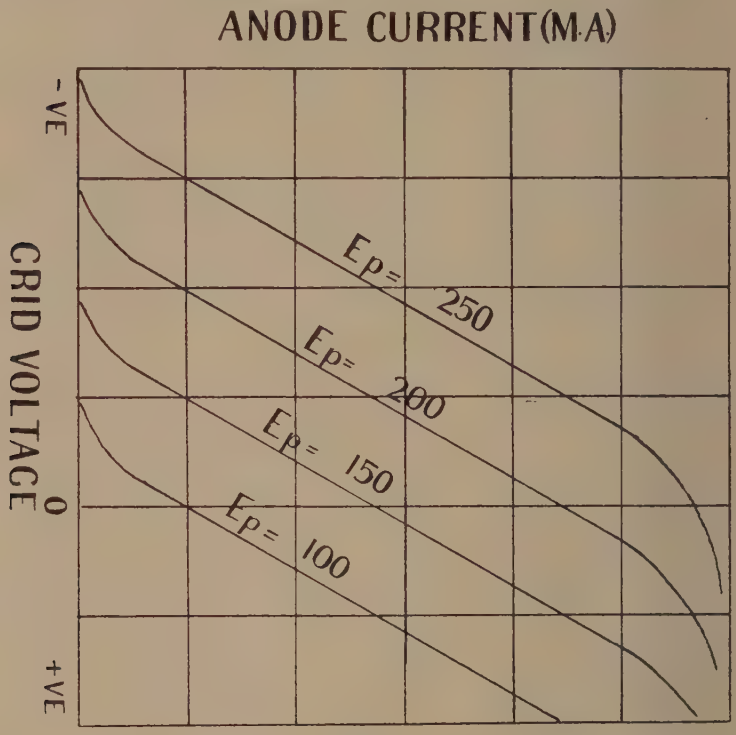

FIG. 1.

Expressed in its most general form the equation for the plate current is

$$i_p = E_p \frac{\delta i_p}{\delta E_p} + E_g \frac{\delta i_p}{\delta E_g} + i_\circ$$

Now for the greater part of their length the characteristics are straight lines and this leads to considerable simplification of the above equations. We can write

$$\frac{\delta i_p}{\delta E_p} = \frac{1}{Z_p}$$

where Z_p is called the valve impedance, and also

$$\frac{\delta i_p}{\delta E_g} \Big/ \frac{\delta i_p}{\delta E_p} = \mu$$

where μ is called the amplication factor of the valve. Over the straight region of the characteristics it is obvious that both Z and μ will be constants. $i_\circ$ is

generally small. Introducing the new symbols, and neglecting i_o, the equation for plate current, to a first approximation, may be written

$$i_p = \frac{1}{Z_p}\left(E_p + \mu E_g \right)$$

The tetrode valve is a further development of the three-electrode valve and contains a second grid which may be used in either of two ways :—

Firstly, it may be placed close to the filament and used as a "space charge" grid. The reason in this case for its proximity to the filament is that in such a position it lies where the "space charge" is most dense. When given a positive potential it serves to neutralise to some extent the "space charge" which would otherwise limit the anode current. The screen grid also takes a current which may be used (*e.g.*, in the case of the American General Electric F.P. 54 Pliotron) to counterbalance random fluctuations in the anode current and so stabilise the circuit (v.i.).

Secondly, the extra grid may be used to screen the control grid against anode potential variations. The operation of the screen grid depends upon its being maintained at a fixed potential. If its potential does not fluctuate as a result of fluctuations of anode potential, then the control grid, which is screened by it, cannot receive energy from the anode and is, therefore, not influenced by it.

The screen grid tube is limited in its power-handling capacity. When the anode potential variations are so great as to bring its potential to a value near the potential of the screen grid, the anode current suddenly drops almost to zero. This is due to the fact that secondary emission effects are produced and the electrons from the plate are collected by the screen grid, thus affecting its potential. In order to overcome this secondary emission effect, a fifth electrode, known as the supressor grid, is inserted between the anode and the screen grid. The result is the modern pentode or five-electrode valve.

EARLY DEVELOPMENTS.

The value of the thermionic vacuum tube as a means of measuring potential difference has long been recognised (2), and the Moullin voltmeter (3) is now a commercial instrument. Goode (4) appears to have been the first worker to suggest the use of the valve in electrochemical problems. Fig. 2 shows the early circuit of Goode.

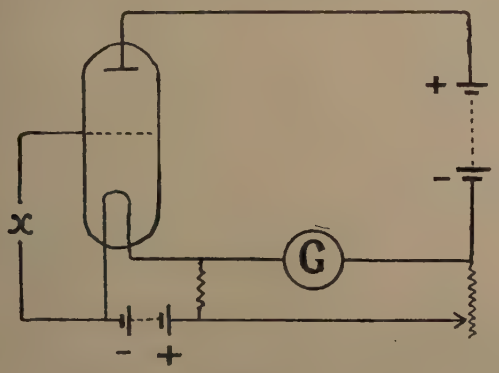

FIG. 2.

The E.M.F. to be measured is connected in the grid circuit of the valve at x and the current through the anode circuit read by means of the galvanometer G. By means of suitable shunts or preferably a suitable back E.M.F. in the anode circuit the scale of the galvanometer may be suitably adjusted and may be calibrated to read the E.M.F. of x directly in volts. Since the cell x undergoing measurement is in the grid circuit of the valve the current drawn from the cell is very small. However, there are several disadvantages in this original circuit :—

1. The sensitivity is not great.

2. The current drawn by the valve (which may be of the order of 10^{-6} amp.), although small, is appreciable and sufficiently large to make the instrument valueless for glass electrode work.

3. There is a zero drift.

The sensitivity may, of course, be increased by means of a valve amplifier, but since this simultaneously magnifies the zero drift, there is little or no improvement in accuracy.

SOME CONSIDERATIONS REGARDING THE CELL BEING TESTED AND THE GRID CIRCUIT.

Let us first consider the effect of cell resistance upon the time required for the grid of the valve to assume the E.M.F. of the cell being measured. In the original treatment of the problem, (1) the internal grid filament impedance of the valve was neglected. This is now taken into consideration. In the diagram, Fig. 3,

C_g represents the grid cathode capacity of the valve.

Z_g represents the internal grid cathode impedance of the valve.

E_x represents the E.M.F. due to electrode assembly, potentiometer, etc.

R_x represents the total resistance of the electrode assembly, etc.

For the calculation it is assumed that the valve is normally operated at "free grid potential," which should be the case when testing high resistance cells.

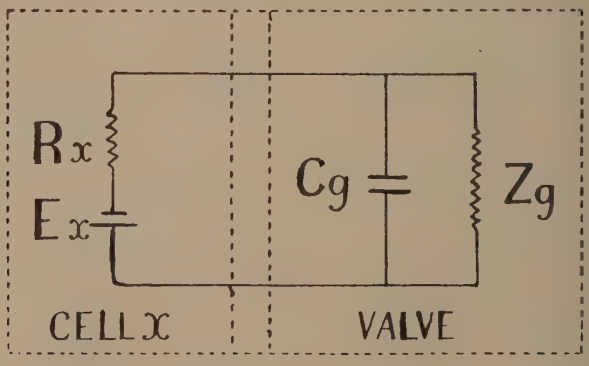

FIG. 3.

Consider the condition when the condenser has a charge Q.

Voltage across the condenser $= \frac{Q}{C_g}$

Rate of flow of current into condenser $= E_x - \frac{\frac{Q}{C_g}}{R_x}$

Rate of flow of current out of condenser $= \frac{\frac{Q}{C_g}}{Z_g}$

Therefore charging current $= \frac{dQ}{dt} = \frac{E_x - \frac{Q}{C_g}}{R_x} - \frac{\frac{Q}{C_g}}{Z_g}$

Integrating $Q = \frac{Z_g}{Z_g + R_x} \cdot E_x C_g \left(1 - e^{-\frac{R_x + Z_g}{Z_g} \cdot \frac{t}{C_g R_x}}\right)$

The ratio of the voltage E', built up across the grid filament circuit to the applied voltage E_x (after a lapse of time t secs.) will be

$$\frac{E'}{E_x} = \frac{Z_g}{Z_g + R_x} \left(1 - e^{-\frac{Z_g + R_x}{Z_g} \cdot \frac{t}{C_g R_x}}\right)$$

Obviously, R_x and Z_g form a potentiometer system which governs that fraction of the voltage E_x which will eventually build up across the condenser. Thus, the final potential which will be built up across the condenser is

$$E'' = E_x \cdot \frac{Z_g}{Z_g + R_x}$$

If we have a glass electrode system with a resistance about $10^8\omega$ and the impedance of the valve is only $10^8\omega$, only 50% of the applied voltage builds up across the valve grid circuit. If Z_g is as high as $10^{10}\omega$, approximately 99% of the applied voltage will become effective across the valve grid circuit. To increase the valve impedance has little further value in this respect.

With a low resistance electrode system, resistance of the order of $10^3\omega$, it is obvious that a valve having a grid resistance as low as $10^5\omega$ will be satisfactory.

Having now arrived at a suitable ratio between the resistance of the electrode assembly and the internal impedance of the valve grid filament circuit, the time constant of the circuit may be considered.

If the ratio of Z_g/R_x be kept to at least 100, the factor $Z_g/(Z_g + R_x)$ is approximately equal to one, and may be neglected when considering the time factor in the grid circuit.

Introducing this simplification

$$\frac{E'}{E_x} = 1 - e^{-\frac{t}{C_g R_x}}$$

which is the same equation as originally published (1).

Considering the case of a glass electrode system having an internal resistance of $10^8\omega$ (about the usual value for modern instruments) and a valve having a grid filament capacity of $3\mu\mu F$ (an average value for small valves such as would be used) and a grid filament impedance of $10^{10}\omega$, it may be calculated that almost the whole of the applied voltage is effective across the valve at the end of one second.

Had the cell resistance been $10^{12}\omega$, it would have been advisable to employ a valve having a grid filament impedance of the order of $10^{14}\omega$. The time constant of the circuit with these values for the components would then become appreciable. At the end of 10 seconds it may be calculated that 96% of the applied voltage is effective across the valve grid circuit.

In order that the full voltage of the cell shall be applied to the grid within a reasonable time, it is necessary that Z_g/R_x shall be large and C_gR_x small. These conditions are naturally more difficult to attain when the electrode resistance (*i.e.*, R_x) is large.

If R_x is $10^8\omega$ and Z_g is $10^{10}\omega$, and the departure from the exact "free grid" potential point is 0·1 M.V., the grid current will be

$$\frac{10^{-4}}{10^8 + 10^{10}} \doteqdot 10^{-14} \text{ amp.}$$

The deviation of the voltage measured, from the voltage of the cell X on open circuit, due to the voltage drop caused by the flow of grid current, will be

$$R_x i_g = 10^8 \times 10^{-14} = 10^{-6} \text{ volt}$$

For comparison it may be mentioned here that the grid current of the special electrometer valves is between about 10^{-13} and 10^{-15} amp. at working potentials (v.i.). They are not operated at "free grid" potential.

The amount of chemical change caused by the flow of grid current may next be considered. One electrochemical equivalent of any substance requires 96,500 coulombs for complete change. Suppose a 0·001 N solution is being investigated, the quantity contained in the electrode vessel being 1 ml. The quantity of substance in this volume of fluid is 10^{-6} equivalent, so that the number of coulombs required to cause complete chemical change is

$$96{,}500 \times 10^{-6} \doteqdot 10^{-1} \text{ coulomb}$$

Now suppose the measurement is completed in one minute, and the current drawn by the grid circuit is 10^{-14} amp., the number of coulombs of electricity passed through the cell in this time is

$$10^{-14} \times 60 = 6 \times 10^{-13} \text{ coulomb}$$

Therefore, the percentage chemical change is

$$\frac{6 \times 10^{-13} \times 10^2}{10^{-1}} = 6 \times 10^{-10} \%$$

From the above reasoning it can be said that, in practice, we are limited to cells having a resistance of about 10^{12} ohms; with average glass electrodes the

current drawn from the cell with quite ordinary valves will be of the order of 10^{-14} amp. ; and further that the amount of electrochemical change will be negligible.

Let us next consider the grid characteristics of a valve. Fig. 4.

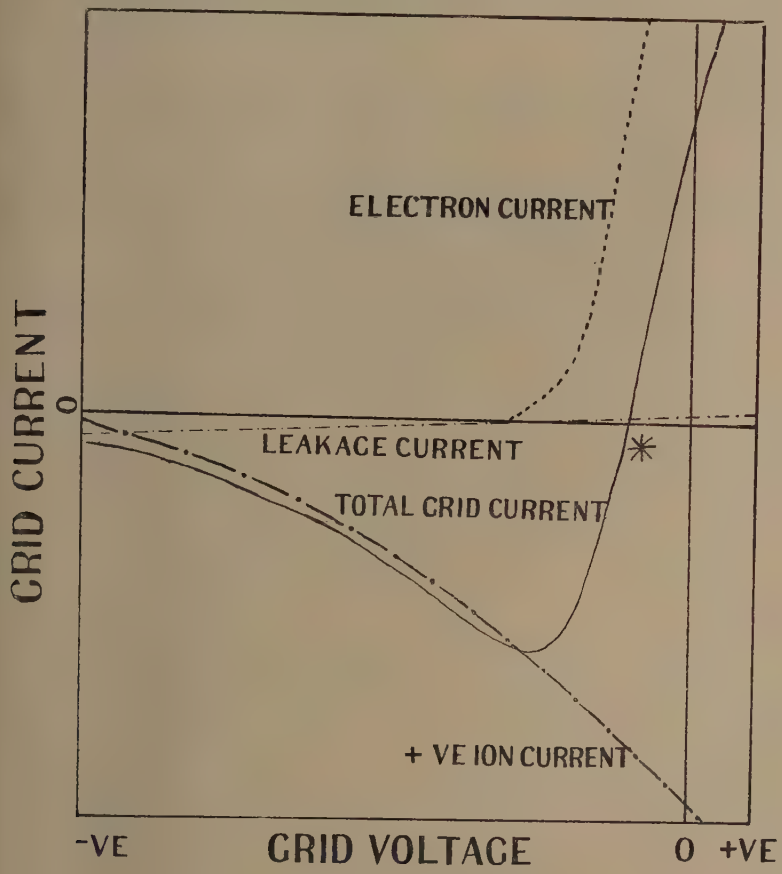

FIG. 4.

It will be noted that the total grid current chiefly comprises three separate currents :—

1. The leakage current from the valve grid to the various other elements.
2. The electron current.
3. The positive ion current.

It should be specially noted that at the point marked * the sum of these currents is zero, so that if the valve is operated at this point no current will be drawn from the external grid circuit. The potential necessary to bring the grid to the point marked * is known as the "free-grid potential." It is the potential assumed by the grid when left on open circuit.

ELECTROMETER VALVES.

Special valves, electrometer tubes, have been designed (15) having a very low grid current. This condition has been arrived at by the following means :—

(a) By supporting the grid assembly on long quartz insulating pillars and taking the grid connection to the top of the tube. This reduces inter-electrode surface leakage.

(b) By using a well thoriated tungsten filament which can be operated at very low temperatures and still produce adequate electron emission. This cuts down thermionic emission and photo-electric emission from the grid (due to light from the filament) and minimises some of the effects in (c).

(c) By using very low anode voltages. This reduces electron emission from the grid due to X-rays produced at the plate by high speed electrons. The voltage is kept low enough to cause little or no ionisation of the residual gas in the tube.

(d) By providing the valves with a screen grid which screens off positive ions (emitted by the filament) from the working grid. Further, the grid may be placed external to the electron current.

The following table gives the characteristics of a number of valves of this class :—

Tube.	E_p	E_{sg}	E_g	E_f	i_f	i_g	$G_m, \left(\frac{\mu A}{V}\right)$
Gen. Elect. F.P. 54	6	4	—4	2·5	110	$\sim 10^{-15}$	~25
A.E.G. T113	7	5	—3	3	100	$\sim 10^{-13}$	~80
A.E.G. T114	6	4	—3	2	80	$\sim 10^{-14}$	~30
L. St. R. II. .... Straub	6	4	—4	2·5	130	$\sim 10^{-14}$	~50
Phillips 4060	4	....	—3	·56	1100	10^{-14} to 10^{-15}	~30
Western Elect. D96475	4	4	—3	1	270	$\sim 10^{-15}$	~40
Mazda UX54	6	4	—4	2·5	100	$\sim 10^{-15}$	~25

The low grid current, however, is obtained at the expense of power handling capacity, amplification factor and mutual conductance. These factors, combined with the fact that the valves should be operated in a rather unstable manner, as will be described later, appear to make them much less desirable from our point of view than the more ordinary radio valves.

THE SINGLE VALVE CIRCUIT.

Penick, in his paper (5), reviews the circuits of Compton & Haring (27), Soller (24), Du Bridge & Brown (23), Harnwell & Van Voorhis (25) and Barth (26), and suggests the following slightly modified Barth circuit as being the best. Fig. 5.

It will be noted that the circuit is a modified Wheatstone Bridge in which the resistance of one of the bridge arms is replaced by the anode filament resistance of the valve. The filament heating current, grid bias voltage, screen grid current and anode current are supplied by the same battery so that by choosing suitable values for the various resistances, it is possible to arrange for the correct grid bias value, anode voltage, filament current, etc., and at the same time arrange

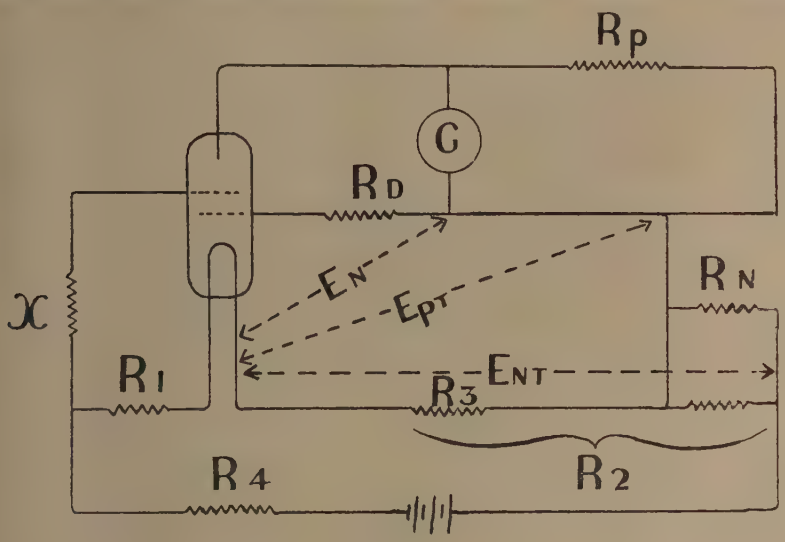

FIG. 5.

that disturbances produced by changes of battery voltage in any one part of the circuit are compensated by changes simultaneously produced in other parts of the circuit. Briefly stated, it is necessary to arrange that—

1. The correct voltages shall be applied to the various electrodes of the valve.
2. The galvanometer current shall tend to zero.
3. The galvanometer current shall be constant for small variations of battery voltage.

The expressions for calculating the values of the resistances required may be derived from the following circuit equations :—

$$i_f R_1 = -E_g \qquad (1)$$

$$i_f R_2 + E_f = E_n + i_n R_n = E_{nt} \qquad (2)$$

$$i_f R_3 + E_f = E_p + i_p R_p = E_{pt} \qquad (3)$$

$$\frac{1 - R_p\left(\frac{\delta i_p}{\delta E_p} + \frac{\delta i_p}{\delta E_n}\right)}{1 - R_n\left(\frac{\delta i_n}{\delta E_n} + \frac{\delta i_n}{\delta E_p}\right)} = \frac{\frac{\delta E_f}{\delta i_f} + R_3 - R_p\frac{\delta i_p}{\delta i_f} + R_1 R_p\frac{\delta i_p}{\delta E_g}}{\frac{\delta E_f}{\delta i_f} - R_2 - R_n\frac{\delta i_n}{\delta i_f} - R_1 R_n\frac{\delta i_n}{\delta E_g}} \qquad (4)$$

Since there are only four equations to be satisfied and the circuit includes 5 variables, the system is flexible. It is thus possible to fix e.g. battery voltage and adjust the resistances to suit. Supposing this voltage to be fixed R_2 may be set at such a value that the required voltage-drop is produced by the normal filament current across the series combination R_2, R_1 and R_f. The value of R_n is then fixed by equation (2) and R_1 by equation (1). R_3 and R_p are left to be fixed from equations (3) and (4). Solving these equations—

$$R_p = \frac{R_n \left\{ \left(\frac{\delta i_n}{\delta E_n} + \frac{\delta i_n}{\delta E_p} \right) \left(E_p + i_f \frac{\delta E_f}{\delta i_f} - F_f \right) - \left(i_n - i_f \frac{\delta i_n}{\delta i_f} + i_f R_1 \frac{\delta i_n}{\delta E_g} \right) \right\}}{\left(\frac{\delta i_p}{\delta E_p} + \frac{\delta i_p}{\delta E_n} \right) \left\{ \left(E_p + i_f \frac{\delta E_f}{\delta i_f} - E_f \right) + R_n \left(i_n - i_f \frac{\delta i_n}{\delta i_f} + i_f R_1 \frac{\delta i_n}{\delta E_g} \right) \right\} -$$

$$\left(1 + R_n \left(\frac{\delta i_n}{\delta E_n} + \frac{\delta i_n}{\delta E_p} \right) \right) \left(i_p - i_f \frac{\delta i_p}{\delta i_f} + i_f R_1 \frac{\delta i_p}{\delta E_g} \right) \qquad (5)$$

$$R_3 = \frac{1}{i_f} \left(E_p + i_p R_p \right) \qquad (6)$$

The stability of the single valve bridge circuit against random battery fluctuations depends upon the condition that the valve operates as a purely ohmic resistance. This is accomplished by running the valve with low filament current so that it is possible to work on the curve of the plate current-plate volts characteristic which occurs towards the saturation current section of the characteristic. A point is selected on this curved part of the characteristic such that the tangent to the curve through the operating point passes through the zero current-zero voltage point. The necessary point is represented by the point * in Fig. 6. Obviously, any change in the operating point, say by valve aging, causes a departure from the necessary condition referred to above.

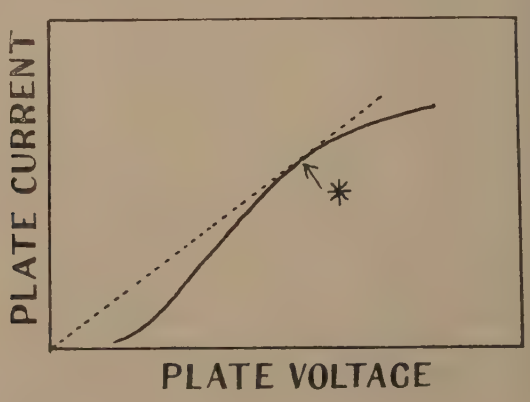

FIG. 6.

THE TWO-VALVE BRIDGE CIRCUIT.

This circuit appears to have been suggested first by Wold (6) and Brentano (7) and developed by Schwarzenbach (8), Stadie (9), Razek & Mulder (10), Stadie, O'Brien & Laug (11), Garman & Droz (12). The two-valve bridge circuit is easier to set up than the single-valve circuits, and has the advantage of greater stability because the valves are operated at a more rational point on the characteristic, *i.e.*, where the characteristic is approximately straight. There is zero galvanometer current for no applied grid voltage. Compensation for anode and filament battery changes may be arranged, and with fairly well matched valves there is approximate compensation for aging of the tubes. This latter feature cannot be arranged for single-tube circuits. Fig. 7 will serve to show the fundamental principles of the two-valve bridge circuit.

If the valves were perfectly matched and $R_1 = R_2$ it would only be necessary to make the tapping point on R_1 the same as the tapping point on R_2, place the anode voltage tap at the mid-point of R_3, place the filament voltage tap at the mid-point of R_4, adjust the grid bias on each valve to the same value by means of the potentiometers P_1 and P_2 to balance the bridge. Unfortunately it is almost certain that the valves will not be exactly the same and it thus becomes necessary to so balance the bridge that compensation is effected for changes of filament and battery voltage and for differences of valve impedance.

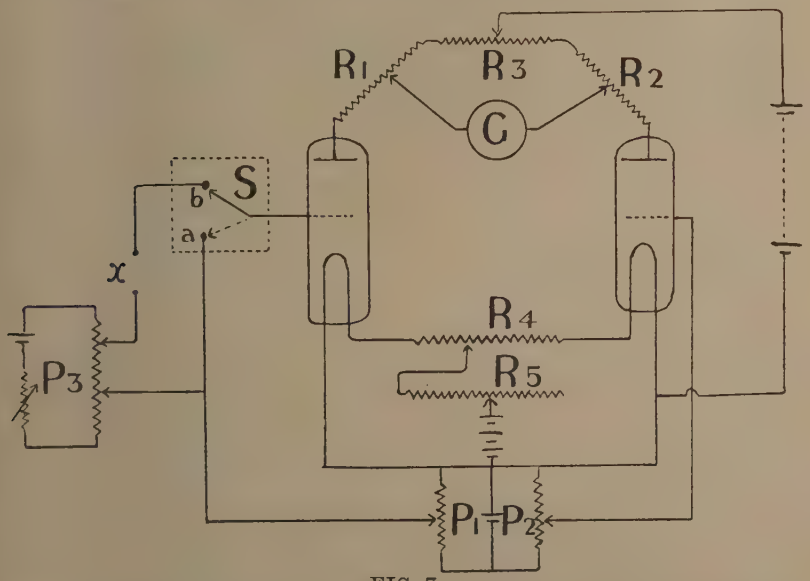

FIG. 7.

This balancing is performed by trial and error, as follows:—The slider is set at the midpoint of R_3 and the sliders set to corresponding points on R_1 and R_2. The slider is set to the mid-point of R_4. The potentiometers P_1 and P_2 are next adjusted, and if the valves are well matched balance will occur when the bias due

to P_1 is nearly the same as the bias due to P_2. Generally, due to differences in the emission from the two valve filaments, balance is upset when the filament current changes, as may be ascertained by varying the contact on R_5. To compensate for this difference of emissivity of the valve filaments the contacts on R_4, P_1 and P_2 are altered until no deflection of the galvanometer occurs when the slider on R_5 is altered. To compensate the bridge for fluctuations of anode battery potential the contacts on R_1, R_2 and R_3 are set so that no galvanometer deflection occurs when the anode voltage is altered. This last adjustment will have slightly upset the filament battery compensation, which must then be reset, and so on.

OTHER METHODS OF STABILISING THE BRIDGE.

A very neat method suggested by Turner (13) for compensating for changes of anode potential is the "μ balance" circuit. This method may be explained as follows:—

The rate at which the anode current of a valve varies with anode voltage, for constant grid voltage and filament current, is very constant for a good valve (with the exception of special types) over the operating range, *i.e.*, the anode current-anode voltage characteristic is straight over the operating range.

$$\therefore \quad \frac{\delta i_p}{\delta E_p} = \text{const.} = \frac{1}{Z_p}$$

Similarly, over the operating range, the rate at which the anode current varies with the grid voltage, the anode voltage being constant and filament current constant, is also very constant, *i.e.*, the anode current-grid voltage characteristic is straight over the operating range.

$$\therefore \quad \frac{\delta i_p}{\delta E_g} = \text{const.}$$

The ratio of the above constants is known as the amplification factor of the valve and is generally denoted by μ, thus—

$$\mu = \frac{\delta i_p}{\delta E_g} \Big/ \frac{\delta i_p}{\delta E_p}$$

This ratio expresses the relative effects of grid voltage to anode voltage on plate current.

The value of μ, the amplification factor, of any tube depends mainly upon the mechanical construction of the tube and only secondarily, and to a minor extent, upon such factors as current.

Now suppose that a potential divider is placed across the current supply to the valve anode filament circuit and from this potential divider is taken off a negative potential equal in value to the anode potential divided by the amplification factor of the valve, and this potential is applied to the grid of the valve. If an increase or decrease takes place in the supply potential tending to cause an increase or decrease in anode current, an exactly countering effect is produced by the change of the grid bias voltage, for an increase of potential produces an increase of negative bias and *vice versa*. The input impedance of such a device is infinite in value. The circuit of Fig. 8 shows the essentials of the scheme.

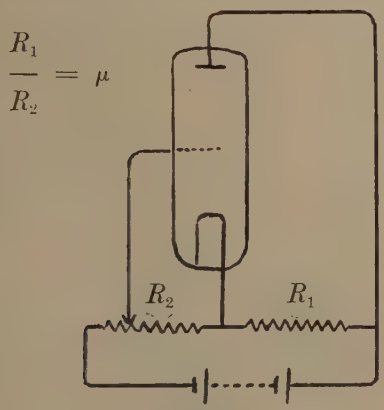

FIG. 8.

However, in general, it will be found impossible to work with the value of the grid bias produced by this scheme unless—

(*a*) the valve has a very high amplification factor ; or

(*b*) it is convenient to bring the grid to the desired operating point by means of a source of constant E.M.F. such as a Weston Cell (12).

This scheme will be particularly difficult to apply when it is desired to work at "free grid potential" because standard cells cannot be shunted by a potentiometer which draws current from the cell.

The relative stability of the μ-balance circuit to other single-valve circuits has been determined by Turner (13). The graphs of Fig. 9 are copied from Turner's paper. The curves show, in relative order of stability, the characteristics of a valve balanced against a resistance, operated as a "pure resistance," and stabilised by the μ-balance method.

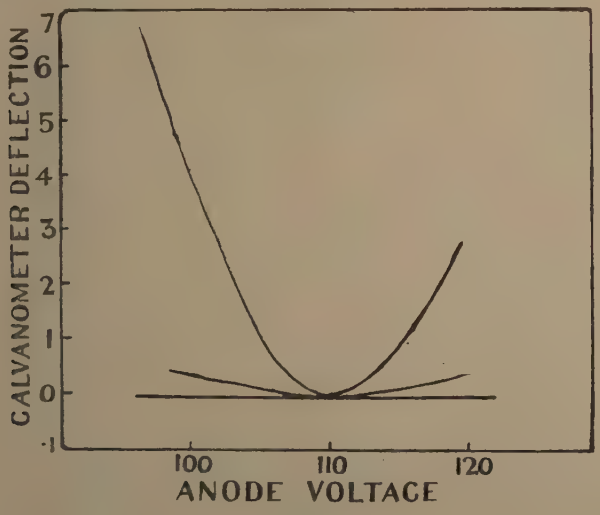

FIG. 9.

Various voltage and current stabilising devices are now obtainable at moderate cost, but no reference has been noted of their use for the type of instrument we are considering.

The first device which seems worthy of attention is the barretter. This consists of a resistance and associated heater generally placed in an evacuated glass vessel to ensure stability. The values of the elements are so arranged that the increased temperature of the heater due to a rise of supply voltage causes sufficient increase in the value of the resistance to produce an increase of voltage drop across the resistance equal to the increase of supply voltage and *vice versa*. The current through the device thus remains substantially constant.

A similar constant current device is obtained by working an iron wire in an atmosphere of hydrogen. It would appear that these devices could well be used to stabilise the filament current of a valve bridge. Fig. 10 shows the characteristics of one of these barretters.

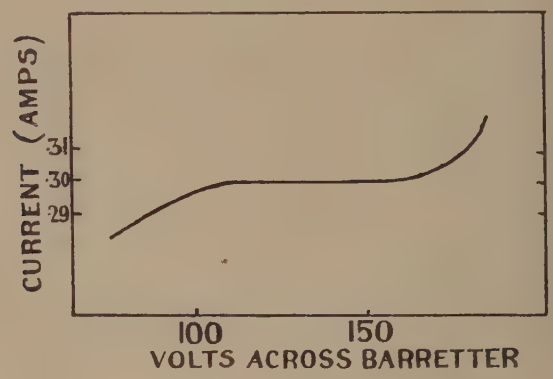

FIG. 10.

Another recently developed device which deserves attention is the glow discharge potential divider and voltage stabiliser (14). The instrument is marketed under the name of the "Stabilovolt Glowgap Divider." Several alternative voltages are available and it is stated that the output voltage does not vary more than $\pm 0{\cdot}2\%$ when the supply of voltage varies $\pm 10\%$ and that it falls about 1–2% as the load is increased from zero to full load. The various voltages are dependent on one another only to the extent of ·01–·02%. The instrument consists of a number of glow discharge gaps in series across the supply voltage. The gaps are mounted in a glass tube which contains gas (neon) at a pressure of a few cms. of mercury. The electrodes are of iron which is coated with some special material. Each intermediate electrode serves as the cathode of one gap and the anode of the next. Once the striking voltage has been reached the current which flows is mainly due to ionisation of the gas molecules by collision with the accelerating electrons, and this current, being thus a cumulative effect, is very sensitive to small changes in the accelerating voltage. The graph, Fig. 11, shows the type of characteristic.

On the applied voltage reaching the value *A* current commences to flow and the applied voltage falls to *B*. If there is no limiting resistance in the circuit (a resistance sufficient to cause a drop of 50% of the working voltage of the tube is required) a destructively large current will flow through the tube.

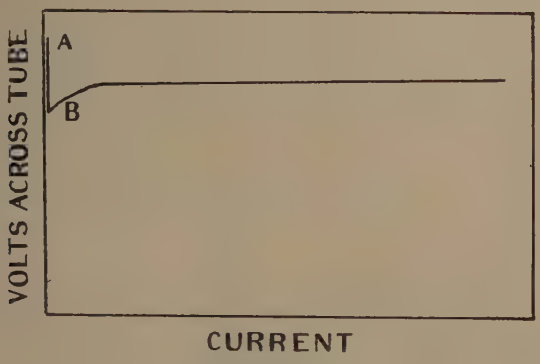

FIG. 11.

The "stabilovolt" functions as a battery of very low internal resistance to the instrument which it supplies with current. Low battery resistance is one of the desiderata for bridge sensitivity as may readily be proved by considering the effect of battery resistance when deriving the current equation for the bridge. It will be found that a further number of terms including battery resistance as a factor, are introduced into the denominator of the equation.

A three-element vacuum tube of the power type supplied with a suitable grid bias would appear to be a most suitable arrangement to use as a source of constant current supply for the glow-gap divider. The grid bias, equal to E_P/μ, should be obtained by a resistance of suitable value in the output circuit. No ballasting resistance would then be required and very little waste of power would result. This scheme is shown in Fig. 12, R_B representing the biasing resistance.

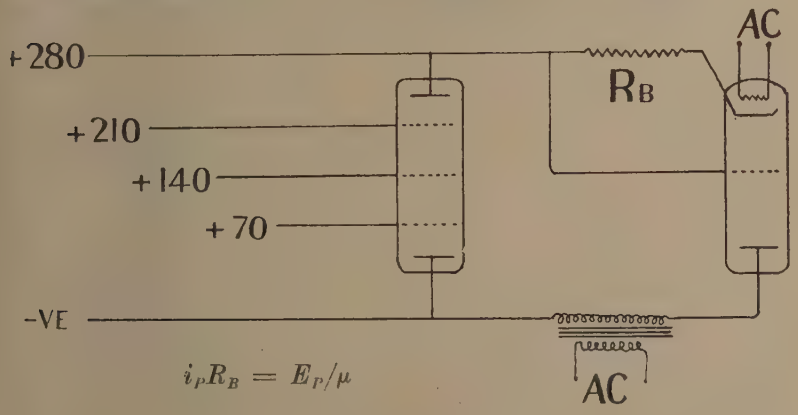

FIG. 12.

It might be thought that an even neater arrangement would be to use a power amplifying valve as the rectifying valve for the bridge supply circuit with the μ-balance circuit arrangement applied to it to obtain a source of constant current. Such an arrangement, however, is not good, for it behaves as a battery of high internal resistance.

OPTIMUM VALUE OF RESISTANCES IN BRIDGE ARMS.

As will be shown graphically later, the sensitivity of the valve bridge potentiometer is greatly influenced by the value of the two valve anode resistances, but past workers do not appear to have derived the expression necessary to obtain the optimum value for them. The expression may be derived as follows :—

Consider the circuit shown in Fig. 13.

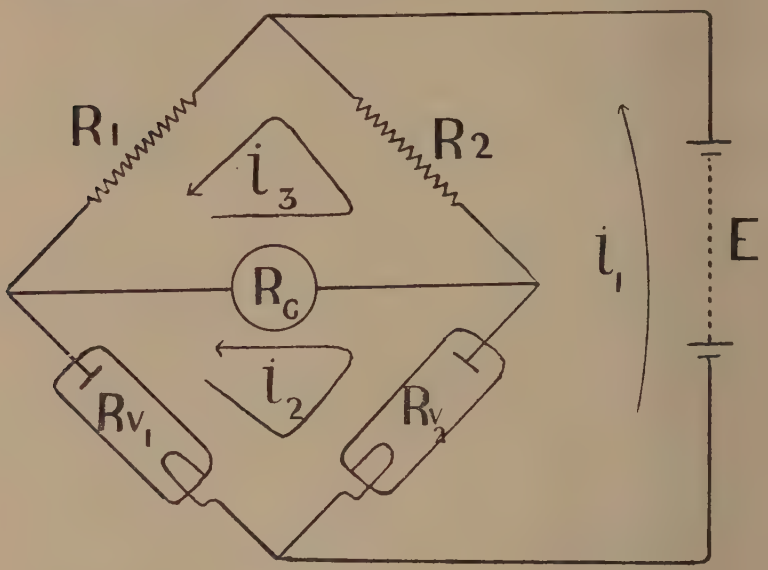

FIG. 13.

From Kirchoff's Laws.

$$E - R_{v_2}(i_1 - i_2) - R_1(i_1 - i_3) = 0$$

$$R_{v_2}(i_2 - i_1) + R_{v_1}i_2 + R_G(i_2 - i_3) = 0$$

$$R_1(i_3 - i_1) + R_1 i_3 + R_G(i_3 - i_2) = 0$$

From these equations it may be shown, by the use of determinants, that—

$$i_2 - i_3 = \frac{E\left(R_1R_{v_2} - R_1R_{v_1}\right)}{R_{v_1}\left(2R_1R_{v_2} + R_{v_2}R_G + R_1R_G + R_1^2\right) + R_1R_{v_2}R_G + R_1^2R_{v_2} + R_1^2R_G}$$

equn. (1).

This expression enables one to calculate the galvanometer current given the supply voltage and the resistance of the various elements of the bridge. The internal resistance of the source of current is assumed to be negligibly small compared with the other resistances : this is true with such devices as the glow-gap potential divider. It should be noted that the resistances R_{v_1} and R_{v_2} are neither true resistances nor valve impedances and may only be called the "effective valve D.C. resistances" for the particular conditions in which the valves are operating. These values should be obtained by dividing the applied potential by the actual current flowing.

The following table shows the galvanometer current (in M.A.) calculated by equation (1) for various values of anode resistance and galvanometer resistance. The values taken for R_{v_1} and R_{v_2} are 70,000ω and 25,000ω respectively which correspond approximately to an anode voltage of 200 volts and grid voltages of —2 volts and —1 volt for a certain valve.

$R_1 = R_2$.	$R_G =$				
	1000.	500.	100.	10.	1.
2	....	....	....	....	2·05
5	....	....	0·24	....	2·34
10	....	....	0·43	1·71	2·44
20	....	....	0·73	2·06	2·50
30	....	....	0·96	....	....
50	0·23	0·43	1·28	2·34	2·54
100	0·42	0·73	1·70	2·44	2·55
200	0·73	1·13	2·04	2·49	....
500	1·26	1·68	2·30	2·51	2·53
1000	1·65	1·99	2·38	2·49	2·51
2000	1·93	2·15	2·38	2·43	2·44
3000	2·01	2·18	2·33	2·37	....
4000	2·03	....	....	....	....
5000	2·03	2·14	2·24	2·26	....
6000	....	....	....	2·21	....
7000	2·00	2·07	2·14	2·15	....
10000	1·90	1·96	2·01	....	....

This data is depicted graphically in Fig. 14. The curves show that the galvanometer current increases very rapidly with the increase of anode resistance up to the optimum value, after which it slowly decreases. Consequently the anode resistances are better kept slightly higher, rather than lower, in value than the optimum.

By differentiation of equation (1) with respect to R_1, it may be shown that maximum galvanometer current is obtained when

$$R_1 = \sqrt{\frac{R_{v_1} R_{v_2} R_G}{R_{v_1} + R_{v_2} + R_G}} \qquad \text{equn. (2).}$$

The above formula (2) may be applied to the problem of valve bridge design as follows:—

An examination must first be made of the i_p–E_p characteristics of the valve it is proposed to use, and the position of the working point corresponding to the "balanced bridge condition" decided. If it is proposed to use the instrument as a null-point indicator for glass electrode work, the "free grid" characteristic must be shown. In the case of the "null-point" instrument a point is selected on the free grid curve not higher than the point of maximum plate current permissible. The plate current corresponding to the selected plate voltage is noted on the graph and the effective D.C. resistance calculated. In the case of the direct reading instrument, it is necessary to choose the point on the characteristic corresponding to the maximum negative grid bias which will be applied, for the valve will then have its maximum "effective D.C. resistance," which is the resistance value which should be chosen for calculating the optimum value for R_1. The

cell being measured should in practice be connected to the instrument to make the grid potential more positive in value. A sufficiently high plate voltage, not greater, however, than will produce the maximum permissible anode dissipation, should have been chosen for the characteristic to give adequate length of working line. The working point having been decided, the "effective D.C. resistance"

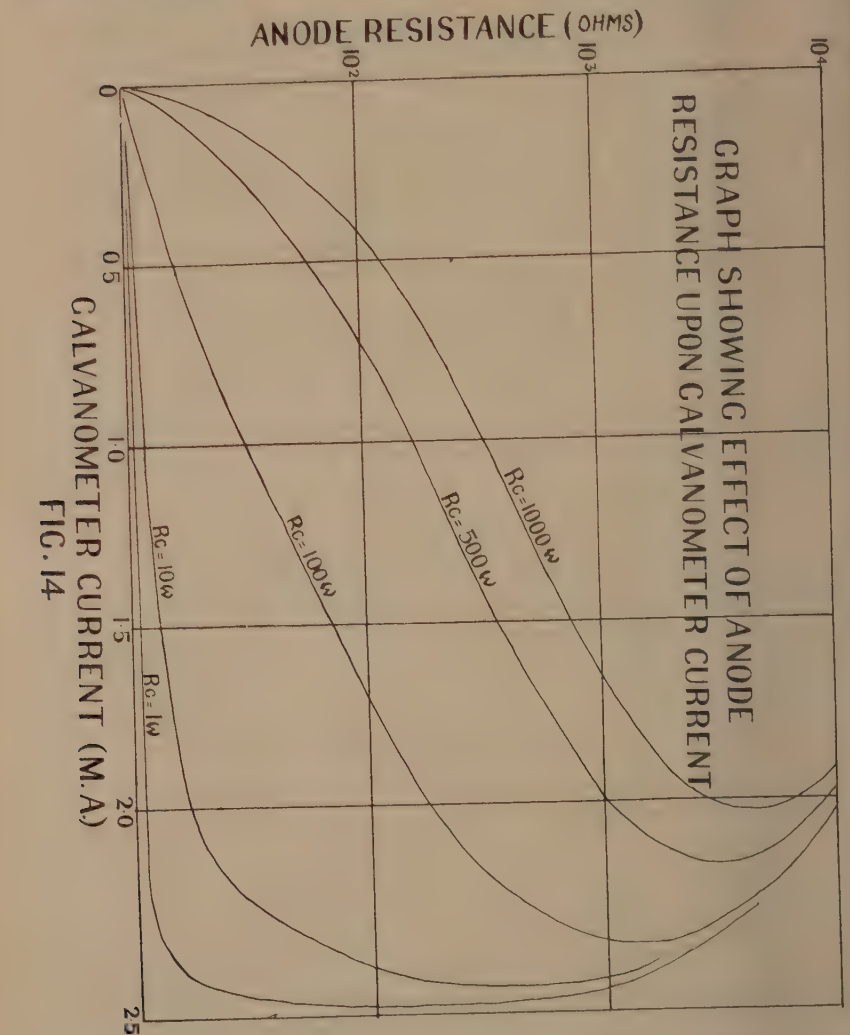

FIG. 14

at this point is calculated from the i_p and E_p values to which it corresponds. At the balanced condition R_{r_1} equals R_{r_2}. We also know the galvanometer resistance. Hence by equation (2) we may calculate the value of R_1. Having found the value of R_1, the voltage drop due to the flow of the plate current through it may be calculated, and this voltage drop together with the voltage across the valve gives the voltage which must be applied to the bridge.

SENSITIVITY OF THE TWO-VALVE BRIDGE CIRCUIT.

This problem has been adequately considered by Nottingham (16), who derived the following equation for the sensitivity of the circuit :—

$$\frac{\delta i_G}{\delta E_g} = \frac{G_m}{2 + R_G\left(\frac{1}{Z_{v_1}} + \frac{1}{R_1}\right)} \qquad \text{Equn. (3).}$$

In this equation G_m represents the mutual conductance of the valve, *i.e.*, the change in anode current caused by unit change of grid voltage.

The galvanometer is critically damped when

$$\frac{1}{R_{cd}} = \frac{1}{2Z_{v_1}} + \frac{1}{2R_1} + \frac{1}{R_d}$$

(where R_{cd} is the critical damping resistance and R_d is the shunt resistance), so that for critical damping of the galvanometer we have—

$$\frac{\delta i_G}{\delta E_g} = \frac{G_m}{2\left(1 + \frac{R_G}{R_{cd}}\right)} \qquad \text{Equn. (4).}$$

CONDITIONS FOR ZERO GALVANOMETER CURRENT OR BALANCE AND INDEPENDENCE OF BATTERY POTENTIALS.

The two-valve bridge is merely a special case of the ordinary Wheatstone Bridge arrangement, so it is obvious that the relation

$$R_1 R_{v_2} = R_2 R_{v_1} \qquad \text{Equn. (5).}$$

(where R_{v_1} and R_{v_2} are the "effective D.C. resistances") must hold for zero galvanometer current.

The current through the valves is expressed most simply by the equations—

$$i_1 = \frac{1}{Z_{v_1}}\left(E_p + \mu E_g + E'\right)_{v_1}$$

$$i_2 = \frac{1}{Z_{v_2}}\left(E_p + \mu E_g + E'\right)_{v_2}$$

Hence, for independence of anode potential changes, the following condition must hold :—

$$Z_1 R_1 = Z_2 R_2 \qquad \text{Equn. (6).}$$

Since Z_1 and Z_2 are constants depending on the valves, we must make

$$\frac{R_1}{R_2} = \frac{Z_2}{Z_1} \qquad \text{Equn. (7).}$$

and then obtain the relationship expressed by equation (5) by altering the grid potential of the balancing valve.

To obtain the conditions which are necessary for independence of filament battery changes, let us consider the equations for the valve currents.

If the filament voltage had been included as one of the variables in the current equations they would have been modified as follows :—

$$i_1 = \frac{1}{Z_{v_1}}\left(E_p + \mu E_g + E'\right)_{v_1} + \left(\phi E_f\right)_{v_1}$$

where $\phi_{v_1} = \left(\frac{\delta i_p}{\delta E_f}\right)_{v_1}$, $(E_f)_{v_1}$ = filament voltage of v_1 etc.

This shows that if the system is to be independent of filament voltage the further relation

$$\frac{\phi_{v_2}}{\phi_{v_1}} = \frac{R_1}{R_2}$$

must hold.

In practice, to compensate, the filaments are run in parallel with a variable resistance in series with one of them.

POTENTIAL MEASUREMENTS AT "FREE-GRID POTENTIAL."

Nottingham (16) has carefully analysed the circuit when operated in this condition. Consider circuit, Fig. 15.

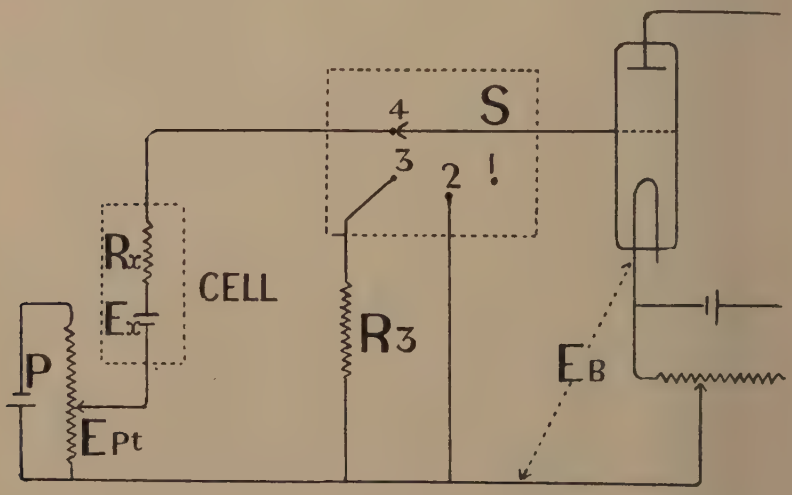

FIG. 15.

Assuming the resistance of the potentiometer P is small compared with the resistance of the cell being examined, we have from Kirchoff's Law

$$E_x + E_{Pt} + E_B = E_g + R_x i_g \qquad \text{Equn. (1).}$$

In order to read the value of the unknown potential E_x directly on the potentiometer we require

$$E_x = -E_{Pt} \qquad \text{Equn. (2).}$$

and this will be true when

$$R_x i_g = O \qquad \text{Equn. (3).}$$

for then

$$E_B = E_g \qquad \text{Equn. (4).}$$

Equation (3) does not have to be absolutely satisfied, and in practice what will be required is that

$$R_x i_g \text{ is small compared with } E_x - E_{Pt} = \delta E$$

where δE is the accuracy required in the measurement of E_x, say about 1 M.V.

The instrument is operated as follows :—

With the switch S in position 1 the bridge is balanced. The switch S is then changed to position 2 and E_B adjusted until the galvanometer again reads zero. There should be no galvanometer deflection now when the switch is moved from position 2 to 1, or *vice versa*. E_B is thus adjusted to free grid potential. As this test is more severe than is really necessary, one may proceed as follows :—The value of R_3 is made as large as R_x, and then the adjustment made as above using the switch in positions 2 and 3. To measure the potential of the cell being examined, the switch S is moved to position 4 and E_{Pt} adjusted to give zero galvanometer deflection. It should now be possible to move the switch S to either of positions 2, 3 or 4 without galvanometer deflection. The potential E_P now equals the potential E_x.

In order to find the rate of change of E_g with E_x we may refer back to an earlier section of the paper, where it was shown that a change, δE_x, of the potentiometer or cell produced a change, δE_g, on the grid, which were related as follows :—

$$\delta E_g = \delta E_x \frac{Z_g}{Z_g + R_x}$$

Then

$$\frac{\delta E_g}{\delta E_x} = \frac{Z_g}{Z_g + R_x}$$

Proceeding to the limit

$$\frac{\partial E_g}{\partial E_x} \quad \frac{Z_g}{Z_g + R_x} \quad \frac{1}{1 + \frac{R_x}{Z_g}}$$

This equation may be combined with the equation for sensitivity of the bridge to grid potential, *i.e.*,

$$\frac{\delta i_G}{\delta E_g} = \frac{G_m}{2\left(1 + \frac{R_G}{R_{cd}}\right)}$$

to give

$$\frac{\delta i_G}{\delta E_g} \times \frac{\delta E_g}{\delta E_x} = \frac{G_m}{2\left(1 + \frac{R_G}{R_{cd}}\right)} \times \frac{1}{1 + \frac{R_x}{Z_g}}$$

Further, defining the galvanometer response to current by

$$C_s = \frac{\delta \theta}{\delta i_G}$$

and including this in the above equation, we obtain

$$\frac{\delta i_G}{\delta E_g} \times \frac{\delta E_g}{\delta E_x} \times \frac{\delta \theta}{\delta i_G} = \frac{G_m}{2\left(1 + \frac{R_G}{R_{cd}}\right)} \times \frac{1}{1 + \frac{R_x}{Z_g}} \times C_s$$

$$\therefore \frac{\delta \theta}{\delta E_x} = \frac{G_m}{2\left(1 + \frac{R_G}{R_{cd}}\right)} \times \frac{1}{1 + \frac{R_x}{Z_g}} \times C_s$$

Rearranging the expression, we obtain

$$\frac{\delta \theta}{\delta E_x} = \frac{G_m}{1 + \frac{R_x}{Z_g}} \times \frac{C_s}{1 + \frac{R_G}{R_{cd}}}$$

The second factor is a function of the galvanometer constants only and the first of the valve constants and cell resistance.

An important property of screen grid tubes is that by adjusting the voltage of the screen grid the internal grid filament impedance may be greatly increased with a much smaller decrease in the value of the mutual conductance, and when using such tubes the optimum conditions for operation should be determined experimentally.

THE ADVANTAGES OF THE TWO-VALVE BRIDGE ARRANGEMENT.

Compensation for all battery changes, and also, in a large degree, compensation for aging of the filaments, may be readily arranged.

With quite ordinary valves the grid current may be kept as low as 10^{-8}–10^{-15} amp. as compared with 10^{-14}–10^{-16} amp. for electrometer valves (21). Studie (11) gives 10^{-14} amp. for his instrument.

These instruments are stable and easy to handle compared with valve electrometers (Stadie (11) and Hoare (21)).

The limit of useful accuracy is 10^{-4} volt compared to 5×10^{-5} for the valve electrometer (21).

The valve sensitivity may be as high as 2·5 MA/volt compared with 0·02–0·03 MA/volt for electrometer valves (21).

SOME PRACTICAL CONSIDERATIONS.

The first matter which should be considered is the relative value of different insulating materials. The highest possible insulation value is required for any material supporting apparatus between the glass electrode and the grid of the valve in the electrometer. It is of importance to consider both surface resistivity as well as volume resistivity.

The following table gives both the volume and surface resistivity of some materials likely to be useful.

TABLE OF RESISTIVITIES.

Material.	Vol. Res. ω/cm^3	Surface Res. ω/cm^2	
		50% humidity.	90% humidity.
Ceresin	$>5 \times 10^{18}$	$>5 \times 10^{17}$	$>10^{17}$
Paraffin (special)	$>5 \times 10^{18}$	9×10^{15}	6×10^{15}
Amber	5×10^{16}	6×10^{14}	10^{11}
Combustion tubing	8×10^{15}	4×10^{12}	10^{9}
Mica (colourless)	2×10^{17}	2×10^{13}	8×10^{9}
Mica (India Ruby)	5×10^{17}	10^{10}	9×10^{7}
Beeswax	10^{16} to 3×10^{18}	....	....
Porcelain (glazed)	....	2×10^{12}	5×10^{8}
Quartz (fused)	$>5 \times 10^{18}$	3×10^{12}	2×10^{8}
Shellac	10^{16}	5×10^{13}	6×10^{9}
Sulphur	10^{17}	7×10^{15}	10^{14}
Beeswax (yellow unrefined)	2×10^{15}	6×10^{14}	5×10^{14}
Bakelite L558	2×10^{16}	8×10^{15}	8×10^{14}
Rosin	5×10^{16}	5×10^{14}	2×10^{14}
Sealing wax	8×10^{15}	2×10^{15}	9×10^{13}
Tetrachlornaphthalene	5×10^{13}	10^{14}	10^{14}

The grid terminal of the valve in the measuring circuit also needs careful attention. A valve should be chosen in which this terminal is placed at the top of the valve. In order to reduce surface leakage over the glass envelope of the valve it should be coated with paraffin wax (9). Surface leakage may also be reduced by placing a guard ring around the envelope just above the bakelite base

(a few turns of copper wire) and applying to the guard ring the same potential as is applied to the valve grid (16). The method of placing the valve in a jar with P_2O_5 to keep it dry and bringing out leads through a rubber stopper (17) will only increase the leakage current, as rubber is a material having poor resistivity values and further the leads are thus brought close together.

The switch in the grid circuit requires careful consideration. The insulation must be of the highest order, and this means using some material such as ceresin, paraffin or sulphur for the mounting. When using high anode voltages for the bridge, as for a deflection instrument, it is essential that the grid circuit should never be open during switching or a destructively high current will flow through the valve. This may be avoided by making the contact arm wide so that it is always in contact with one of the studs, either one connected to the low resistance cell or one connected to a grid leak. When changing cells, etc., the grid circuit should first be closed by switching in a resistance of a couple of $M\omega$ (*e.g.*, a grid leak). The cell being measured is only momentarily shorted through this comparatively high resistance.

High value grid resistances are best made by drawing a line 1 mm. wide and of length 1 cm. for each $M\omega$ of resistance with Higgin's India Ink on smooth onion skin paper. The resistances should be sealed in tubes of dry air, or evacuated tubes. For high resistance values the line is drawn in the form of a grid (Fig. 16). These resistances have been found perfectly satisfactory (16, 18) and to have a lower temperature coefficient of resistance than the alcohol Xylol resistances of Campbell (19).

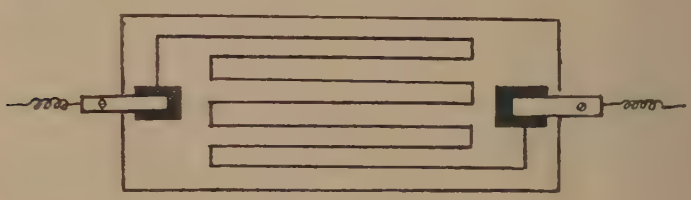

FIG. 16.

The following measurements of temperature coefficients are taken from Nottingham's paper (16) :—

$$R_t = R_{23}[1 + \alpha(t - 23)]$$

R_{23} in ω.	α
$0{\cdot}85 \times 10^6$	$-2{\cdot}7 \times 10^{-3}$
750×10^6	$-6{\cdot}4 \times 10^{-3}$
2100×10^6	$-6{\cdot}4 \times 10^{-3}$

All potentiometers associated with circuits carrying current for the bridge should be placed in parallel with fixed resistances which should carry the main current so as to avoid disturbances in the circuit (16, 20).

As the various balancing resistances may in certain cases be carrying different currents, *e.g.*, in a direct-reading instrument, they should be made of material with a low temperature coefficient of resistance.

Special Galvanometer Shunt.

Nottingham (16) has designed a special shunt for the indicating instrument. Shunts are especially useful with direct-reading instruments. Fig. 17 shows the circuit of the Nottingham shunt.

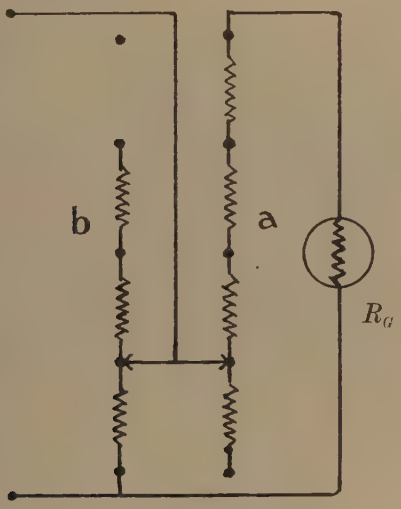

FIG. 17.

The shunt is designed so that the damping of the galvanometer is kept constant, but the current is reduced to the required percentage.

If R_{cd} = critical damping resistance

$$n = \text{sensitivity ratio} = \frac{\text{sens. max.}}{\text{sens. n.}}$$

R_a = resistance in branch a

R_b = resistance in branch b

we have the relation

$$R_a = R_{cd}\left(\frac{n-1}{n}\right)$$

$$R_b = R_{cd}\left(\frac{1}{n-1}\right)$$

The values of R_a and R_b are independent of the galvanometer resistance and the shunt is of a universal type.

The standard Ayrton shunt suffers from the minor disadvantages that—

(*a*) there are errors in the sensitivity ratio ;

(*b*) there is non-uniformity of damping ;

(*c*) there is loss of sensitivity.

Protection of the Indicating Instrument.

To protect the indicating instrument against break-down due to the passage of excessive current should a valve burn out, the filaments may be connected in series.

Choice of Valves.

Valves should be chosen because of their high value of mutual conductance and high input impedance. The grid terminal should be placed at the top of the tube. Dull emitter, or better still, indirectly-heated cathode valves are preferable to others because their filament emission is more constant over a long period. For a deflection or direct-reading instrument the valve should have sufficient length of straight characteristic in the operating region.

Shielding.

The instrument should be placed in a metal case which is grounded. The grid lead to the active valve should be as short as possible and conducted through a metal tube which is also grounded. Stadie (11) connects a small ($\cdot 003 \mu F$) condenser between the active grid terminal and the metal case, but this seems open to some objection as the mica is not of such high resistance value as might be desired and the leakage path is of large size and short.

ACKNOWLEDGMENT.

The writer desires to express his sincere thanks to Dr. G. A. Elliott, University of W.A., for his help in checking the original mathematical proofs used in this paper.

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PURE CULTURES OBTAINABLE FROM PLANT PATHOLOGY BRANCH.

Pure cultures of the nitrogen-fixing bacteria which form nodules on the roots of certain species of the family *Leguminosae*, may be obtained, on application to the Plant Pathologist, in the quantities, and at the prices, indicated below.

APPROXIMATE AMOUNT OF SEED WHICH MAY BE TREATED WITH ONE BOTTLE OF CULTURE.

Size of bottle.	Price. (Post free.) s. d.	Seed of size of lucerne or sub-clover, etc.	Seed of size of garden pea, lupin, soy beans, etc.	Milk required.	Tri-calcium phosphate. (Supplied free.)
1 oz.	1 6	Up to 15lbs.	Up to 30lbs.	½-pint	1.5 gms.
2 oz.	2 6	Up to 30lbs.	Up to 60lbs.	½-pint	3.0 gms.
8 oz.	5 0	Up to 120lbs.	Up to 240lbs.	1 quart	12.0 gms.

DIFFERENT BACTERIA REQUIRED FOR DIFFERENT KINDS OF LEGUMES.

The strains of bacteria which may be obtained from the Department will inoculate the following groups of legumes. *The members of each group are inoculated by the same strain of bacteria, but the plants mentioned in different groups require different bacteria.*

Group A.—Subterranean clover, drooping-flowered clover, ball or cluster clover, white Dutch clover, perennial red clover ("cow grass"), Egyptian clover, (Berseem clover), and all other true clovers (*Trifolium spp.*).

Group B.—Lucerne, white sweet clover (*Melilotus indica*), "King Island Melilot" ("Hexham scent"), medics, trefoils, and all other species of *Medicago or Melilotus.*

Group C.—Garden pea, sweet pea, field pea, Tangier pea, all kinds of vetches or tares, broad bean, tick bean, lentil.

Group D.—W.A. blue lupin (*Lupinus varius*) and N. Zealand blue lupin (*L. angustifolius*).

Group E.—Soy beans (*Glycine Max*).

Group F.—Sulla (*Hedysarum coronarium*).

Group G.—French beans (*Phaseolus vulgaris*), scarlet runner bean (*Phaseolus multiflorus*).

Group H.—Cow peas (*Vigna sinensis*), peanuts (*Arachis hypogoea*), Japan clover (*Lespedeza spp.*), Lima bean (*Phaseolus lunatus*).

Group J.—*Lotus major* and other *Lotus* species.

It is very important that persons ordering cultures should specify very clearly the kind of seed to be inoculated. If "pea" bacteria are ordered, for example, it is impossible to tell whether "garden" peas or "cow" peas, etc., is meant, unless the qualifying word is also indicated. The same thing applies to French and broad beans.

Full instructions for usage are enclosed with the cultures.

Owing to the time taken to prepare the cultures, and owing also to the fact that all orders have to circulate through the Accounts Branch before reaching the Plant Pathologist and that in the busy time of the year there is frequently a tremendous accumulation of orders, farmers are requested to lodge their applications, with the requisite payment enclosed, at the Department a fortnight at least before they wish to use the culture.

RECENT EXPERIMENTS WITH "MINOR" ELEMENTS IN WESTERN AUSTRALIA.

(A series of four short papers.)

I. A brief review of the "minor" element question in Western Australia.

II. Experiments with "minor" elements on the growth of potatoes, vegetables and pastures.

III. Response of wheat to copper on light land at Wagin.

IV. The effect of "minor" elements on the growth of wheat in other parts of the State.

I.—A BRIEF REVIEW OF THE "MINOR" ELEMENT QUESTION IN WESTERN AUSTRALIA.

By L. J. H. Teakle,
Department of Agriculture.

Probably the most characteristic features of the soils of the agricultural areas of Western Australia is their extreme patchiness. This may be explained by a consideration of the possible geological history of this portion of the State where the country rocks consist of a mass of very ancient rocks including altered sediments and granites intersected with basic dykes. The forces of erosion planed down the surfaces to a gently undulating plain and, in the course of time, there developed a covering of highly leached sandy, and ironstone gravelly, soils which we commonly call laterite. In recent times further erosion took place and large valleys were cut through this plain exposing the country rock. The gravelly soils were washed away or redistributed in the course of the valley formation and the granites, sediments and basic rocks exposed to soil forming agencies. As a result, the most fertile soils of Western Australia occur in the valleys, and are richest where the basic dykes have been exposed. Over the agricultural areas the sands and gravels, either *in situ* or redistributed, predominate. The soils formed on these materials are of low fertility and the existence of sub-optimal nutritional conditions is to be expected. These conditions are reflected by the plant growth and by the response of the grazing animals to the pastures on which they graze.

Except for favoured areas of limited extent early settlers found it difficult to grow crops without liberal fertilisation. They used animal manures as far as possible and guanos were applied where available. In the Albany district, they are reported to have used decayed fish on a small scale.

It was the introduction of superphosphate about 1908 which really made extensive agriculture possible in Western Australia, and the resulting development has led to the discovery that other soil amendments are needed on some soil types. Strangely enough, potash and nitrogen have proved valuable only under restricted conditions, but in certain districts the so-called "minor" elements have recently given remarkable responses with crops and animals and promise to be of considerable importance in Western Australian agriculture.

Until about 20 years ago it was thought that only about 10 elements were necessary for the growth of crops and of these the soil supplied seven, namely, calcium, magnesium, potassium, iron, nitrogen, phosphorus, and sulphur. During

the next ten years plant physiologists discovered that a number of other elements were required for plant growth, but they were required in very small amounts; such small amounts that they were called "minor" elements. For a time these minor elements were regarded as laboratory curiosities rather than of practical importance, but now a number are required under field conditions in all parts of the world to maintain the healthly growth of crops and are used as regular fertiliser applications. Amongst the most important of these "minor" elements are copper, manganese, zinc and boron.

The deficiency of a "minor" element in a soil for any particular crop is generally associated with subnormal growth, chlorosis, and other symptoms of malnutrition. Symptoms vary with the crop, the element concerned and the severity of the deficiency so that considerable experience is necessary for diagnostic purposes. Overlapping of the symptoms frequently occurs and makes diagnosis more difficult.

Examples of important responses to "minor" elements in Western Australia may be recalled.

(1) *Copper.*

The Young brothers of Young's Siding, near Albany, remember using bluestone for the growth of oats about 60 years ago. Wickens (1924) and Pittman (1936) have pointed to the use of copper for the cure of exanthema of citrus, Japanese plums and apples. Pittman (1935) has found mottle leaf of figs to be controlled by means of copper. More recently, Bennetts (1937) has shown enzootic ataxia of sheep at Gingin to be related to copper deficiency, and observations in the Dandaragan district indicate a widespread occurrence of copper deficiency with respect to oats. Dunne (1938a), (1938b) has found copper to be effective in controlling "wither tip" of apples.

The results reported in subsequent papers of this series will show that copper promises to be of considerable advantage on certain acidic soil types in the Albany district and at Wagin. A variety of crops shows marked response and with copper sulphate included in the fertiliser mixture, certain characteristic symptoms are eliminated and it will probably be possible to produce a new range of crops on a number of important soil types.

(2) *Manganese.*

Carne (1927) first recognised the grey speck disease of oats in the Dwarda district. Subsequently a survey made by Teakle, Thomas and Hoare (1933) showed that manganese deficiency was probably not widespread in Western Australia. However, conditions under which manganese deficiency does occur have been described by Wild (1934) and Adams (1937). These writers show that cereals are liable to need manganese fertilisation on somewhat acidic, powdery, gravelly soils of the 15 to 25 inch rainfall belt. Legumes are more tolerant of manganese deficiency than cereals.

In the present experiments the most important responses to manganese appear on marly peats. For certain crops on these types, copper in addition to manganese may be required.

(3) *Zinc.*

The value of zinc in Western Australia for promoting the growth of crops was shown by Pittman and Owen (1935), who found that zinc sprays would cure mottle leaf of citrus. Kessell and Stoate (1938) described the remarkable effect of zinc

in stimulating the growth of unhealthy pines affected by "rosetting" on the coastal sands south of Perth. Hearman (1938) reported that pines affected by "rosetting" were stimulated, also, by injection of manganese sulphate, ferrous sulphate, cobalt chloride, nickel chloride, sodium molybdate and boric acid.

No beneficial effects from zinc have been observed in the experiments reported in the subsequent papers but severe injury to wheat resulted from the use of zinc sulphate at the rate of 20 lbs. per acre on the Wongan Hills Research Station.

(4) *Cobalt.*

Underwood and Filmer (1935) (1936) succeeded in showing that minute quantities of cobalt were curative of the Denmark wasting disease of cattle and sheep. The incidence of the disease is correlated with a low cobalt status of the soils and pastures (Harvey (1937), Underwood and Harvey (1938)).

The evidence reported in the subsequent papers of this series shows that "minor" element deficiencies in soils appear to be associated with the "deterioration" of potato seed in the Albany district and the rapid decline in the yield of potatoes after a satisfactory first crop on certain soil types in the same locality. Furthermore, the failure of efforts to establish certain crops and pasture species on certain soils is undoubtedly due to inadequate supplies of available "minor" elements of which copper is of prime importance. The evidence from Wagin suggests that many cases of wheat failure and the development of white heads on gravelly sandy soils may be improved by the use of copper salts.

Conclusion.

The observations reported in this paper are published at the present juncture on account of the widespread interest of farmers in the use of "minor" elements in Western Australia. It is true that very spectacular results from the use of a number of "minor" elements have been obtained and there is no doubt that further experimentation and survey will establish the value of certain of these constituents under many conditions of Western Australian agriculture.

But it is not to be supposed that the mere use of small quantities of "minor" elements will revolutionise Western Australian agriculture. The majority of our soil types at present under cultivation are probably adequately supplied in these constituents at least for the immediate future and experiments are reported in which no benefits have resulted. In fact, it is evident that even small quantities of some "minor" elements may be distinctly injurious to wheat and other crops under certain conditions. Indiscriminate application of these fertilisers by farmers is ill-advised and will certainly lead to loss of money and, perhaps, to reduction in crop yield under many circumstances.

However, advantage must be taken of the positive results which do give promise of enabling farmers to develop considerable areas of virgin country in settled areas under a generous rainfall and of improving crop and pasture returns and, incidentally, the nutrition of the grazing animals on many soil types. On some soil types the use of copper and of manganese promises to retard soil "deterioration" and simplify farm management: to avoid the need for potato seed introduction and the consequent hazard of disease dissemination. Certain of these "minor" elements promise to promote the growth of crops and pasture species where these had failed under ordinary farm practice.

There is strong evidence of the value of manganese on marly peats and of copper on certain types of acidic peaty sands and mucks in the Albany area: of copper for wheat on types of gravelly sand in the Wagin district. It is necessary

to extend the research programme to determine by survey and experiment the conditions under which response is likely and the crop symptoms which will indicate possible deficiencies.

In the absence of more precise information farmers are advised to use great caution in the use of "minor" elements. Rates should be kept low—not more than 15 lbs. per acre should be adequate under most conditions. Until experience has been obtained small areas should be treated for comparison with crops grown under ordinary conditions as without comparisons no conclusions may be drawn in most cases. Above all, farmers are advised to carry out tests with "minor" elements on their farms only after receiving the advice of the Department of Agriculture. By this means the risk will be minimised and any information obtained may be properly evaluated and used for the benefit of other agriculturists.

II.—EXPERIMENTS WITH "MINOR" ELEMENTS ON THE GROWTH OF POTATOES, VEGETABLES AND PASTURES.

By L. J. H. Teakle and E. T. Morgan,
Department of Agriculture.

1. *Introduction.*

The failure of various crops to make satisfactory growth in spite of suitable climatic conditions and generous fertiliser treatment on soils of favourable physical properties has led to much successful work with "minor" elements all over the world. Successes with these amendments in Western Australia have already been mentioned in Paper I. and it is the purpose of this communication to give the results of further experiments with potatoes, vegetables and pastures.

The first indication of the possible lack for the growth of potatoes of some other constituent than is usually applied in mixed fertilisers came from the apparent need for very heavy dressings of superphosphate (10-12 cwt. per acre) for maximum returns. Further evidence was provided by the "deterioration" of potato seed in some localities, the "deterioration" of certain types of potato land, the occurrence of "thready" eye and similar weaknesses in the tubers, and unthrifty growth of tops under some conditions. The failure of various truck crops on certain soils and difficulties in pasture establishment pointed to undetermined soil deficiencies.

In early experiments with potatoes disappointing results were obtained. Palmer (1933), using copper sulphate in the fertiliser mixture for potatoes, found a slight response on the Herdsman marly peat. Morgan (1938) found no response to a mixture of copper, manganese, zinc and magnesium at Burekup on the western coastal plain, near Bunbury. This finding may be explained by the results of spectrographic analyses made by Professor N. S. Bayliss, of the University of W.A. The pulp of a potato grown at Benger (Mr. T. Offer), a little north of Burekup, showed a high content of "minor" and other elements (copper, boron, manganese, iron, cadmium, barium, sodium and cobalt) as compared with samples from Young's Siding (Mr. E. Smith and Mr. R. Wolfe), in which district marked responses have now been obtained.

2. *Responses on marly peat soils on Mr. B. H. Burvill's property, Little Grove, Albany.*

The first responses of significance were observed in the Albany area where, in the 1936-37 season, Mr. B. H. Burvill tested the effect of manganese on a number of truck crops grown on a marly peat soil at Little Grove.

Although the first crops grown after clearing these swamps did fairly well, the succeeding ones were failures for no apparent reason. Resemblance of the soil to certain types described on the Florida Everglades prompted the application of manganese sulphate to potatoes, beans and cabbages. The result was very gratifying with all crops, but particularly outstanding with beans. Later it was observed that manganese sulphate was of benefit also to swedes, turnips, tomatoes and peas, and that copper sulphate, in addition to manganese, improved the cabbages, swedes, turnips, tomatoes and peas. The particular value of copper to peas lay in the formation of well filled pods instead of the usual "puff boxes" or empty pods when only H manure* was used.

In the 1937-38 season experiments on this type of soil were organised by the Department of Agriculture to get more precise information with a number of crops. Yields of potatoes are given in Table 1.

TABLE 1.

Yields of potatoes on marly peat soil on Mr. B. H. Burvill's property, Little Grove, Albany. "Minor" elements, except boron, were applied as commercial sulphates at the rate of 20 lbs. per acre.

Fertiliser.	Yield per acre.		Per cent. of Control.
	tons.	cwt.	
Control—Manure E†	6	0	100
Plus magnesium sulphate	5	9	91
,, copper sulphate	5	14	95
,, zinc sulphate	7	3	119
,, borax (20 lbs. per acre)	6	16	114
,, manganese sulphate	8	10	142
,, manganese sulphate, copper sulphate ...	8	12	143
,, manganese sulphate, copper sulphate, zinc sulphate	9	9	158
,, manganese sulphate, copper sulphate, zinc sulphate, magnesium sulphate, borax	8	8	140

Significant difference is 1 ton 3 cwts. per acre ($P = 0.05$).

The only really significant response with potatoes was to manganese. It was noted, however, that copper improved the colour of all crops treated.

With swedes and cabbages growth was greatly improved by both copper and manganese but no harvest returns were obtained. Mr. Burvill reported that swedes grown with copper and manganese were ready to pull at least a fortnight earlier than the controls. Beans did not mature on account of frost but showed early response to manganese.

In the 1938-39 season a commercial crop of swedes was sown on the site of the experiment with beans. A marked residual effect due to the minor elements was observed but the individual plots had lost their identity in ploughing.

A complex 3 x 3 x 3 x 3 factorial experiment with potatoes was arranged for 1938-39. It was planted during the first week in December but headway was slow owing to the dry early summer conditions. Top growth reflected the treatments,

* Manure H has the following composition: 4% nitrogen, 13.7% P_2O_5 and 9% K_2O.

† Manure E contains 3.5% N, 15% P_2O_5, and 8% K_2O.

however, and showed marked improvement on all plots receiving manganese either at the rate of 20 lbs. per acre or 40 lbs. per acre. Copper, zinc and boron were without apparent effect. Without manganese the plants were stunted and showed a bronze yellow chlorosis, particularly between the veins. With manganese the plants were a normal green and promised a fair yield until destroyed by floods on 13th January, 1939. The area has been sown with oats to determine the residual effect of the treatments on this crop, and a similar experiment is planned for the coming season.

3. *Responses on acidic swamp soils on Mr. C. T. Hortin's property, Bornholm.*

The deterioration of locally grown potato seed in the Albany district has caused great concern and, in many instances, necessitated the introduction of seed from other districts, for example, Benger on the coastal plain south of Perth. The introduction of seed from other districts complicates potato growing and is undesirable on account of the spread of diseases.

Fig. 1 shows the relative growth from local and Benger seed on sandy swamp karri land on Mr. E. Cake's property, Young's Siding.

Fig. 1.
Potato tops from Mr. E. Cake's farm, Young's Siding, without "minor" element treatment. Left: two plants from local seed. Right: one plant from Benger seed.
Photo.: L. J. H. Teakle.

The first indication of the benefit from minor elements in maintaining the vigour of Albany seed arose from an experiment on Mr. C. T. Hortin's swamp at Bornholm in the 1937-38 season. The soil is a black acidic muck to sandy muck (pH 4.2) and very productive but gave marked increases in yield as a result of using minor elements. In the preliminary experiment, a mixture of "minor" elements consisting of commercial sulphates of copper, manganese, zinc and magnesium and borax each at the rate of 20 lbs. per acre was used with a "complete"* fertiliser compounded from 5 parts of superphosphate, 1 part of sulphate of ammonia, and 2 parts of sulphate of potash.

* A "complete" fertiliser contains nitrogen, phosphorus, and potassium.

The results of the experiment are given in Table 2.

TABLE 2.

Effect of minor elements on the growth of potatoes on Mr. C. T. Hortin's swamp, Bornholm.

Fertiliser.	Yield per acre.		Per cent. of Control.
	tons.	cwt.	
"Complete" fertiliser—8 cwts per acre ...	9	13	100
"Complete" fertiliser—16 cwts per acre ...	11	10	119
"Complete" fertiliser—8 cwts per acre, plus "minor" elements	12	18	134
"Complete" fertiliser—16 cwts per acre, plus "minor" elements	13	12	141

The minor element mixture materially increased the yield, reduced the need for heavy dressings of "complete" fertiliser and, in addition, eliminated the appearance of "stem end" rot in the tubers.

Fig. 2 shows the comparison of tubers from plots with and without "minor" elements.

Fig. 2.

Potatoes from Mr. C. T. Hortin's experimental area, Bornholm, harvested April, 1938. Top row: smooth, blocky tubers with vigorous eyes from plots receiving "minor" elements. Bottom row: rough, pointed tubers with scaly skin from plots receiving no "minor" elements.

Photo.: Government Printer.

Immediately following the digging of the potatoes oats were sown on the experimental area in March, 1938. Spectacular growth was made on the sites

of the minor element plots. The plants were erect, tall, green and vigorous and the leaves showed a prominent mid-rib. Over the rest of the area the symptoms suggested that copper was the active ingredient as they closely resembled those described by Riceman and Donald (1938). The plants were yellowish tipped, weak in the stem and poorly rooted. Weighings indicated that the treated areas would yield about 11 tons of green material per acre while only 2 tons could be expected from the land which had not received minor elements.

Fig. 3 shows the growth of oats with and without "minor" elements.

Fig. 3.

Growth of oats on Mr. C. T. Hortin's experimental area, Bornholm, 1938. Left: without "minor" elements—14 ozs. green material. Right: with "minor" elements—84 ozs. green material. Photo.: E. T. Morgan.

A more critical 3 x 3 x 3 x 3 factorial experiment was planted on adjacent land of the same type in the first week of December, 1938, and the growth of the tops observed five weeks later at the beginning of flowering. As the characteristic improvement in top growth occurred only on the plots treated with copper it was apparent that copper was the most important active ingredient in the mixture used the previous year.

The floods of 13th January, 1939, wiped out the crop so no harvest returns are available.

Fig. 4, on following page, shows the effect of the flood on the potato crops.

An oat crop has been sown to determine the residual effect of the treatments.

The effects of copper on potatoes grown on copper deficient land are: the foliage is more vigorous and the leaves a paler green colour than in the controls, the stems are thicker and more erect, and there is a strong development of branches and subsidiary stems, flowering is more profuse and prolonged. As shown in Fig. 2, the tubers are cleaner, healthier and of better quality, the eyes are stronger and more deeply set, and the "eyebrow" is more pronounced. On sprouting, vigorous pink shoots are produced and the succeeding crop reflects the extra quality of the seed from the plots receiving copper.

4. *Responses on other soils of the Bornholm and Young's Siding districts.*

The results with potatoes and oats so impressed farmers of the Albany district that several tons of bluestone were used during 1938 on a variety of crops and soil types. In the majority of cases very satisfactory responses were obtained from dressings ranging from 8 to 15 lbs. of copper sulphate per acre.

a. Mr. C. T. Hortin's property, Bornholm, 1938.

On a brown sandy soil, about 3 feet in depth, on a karri hill, barley was greatly improved by a top dressing with powdered bluestone at the rate of 15 lbs. per acre. Without copper, and in spite of a dressing of potato manure, the barley was poorly rooted and easily pulled up, the stems weak and prostrate, the sheaths pale and the leaves showed a whitish or yellowish tipping and yellow edging. With copper, in spite of an initial burning, normal growth was made. Likewise, garden peas dressed with potato manure (5 super., 1 sulphate of ammonia, 1 blood and bone, and 2 sulphate of potash) plus copper sulphate produced excellent well filled pods.

Fig 4.
Effect of flood water on a good crop of potatoes on C. T. Hortin's swamp. Experiment area.

Without copper, the plants made normal vegetative growth but the pods failed to fill. Onions and lettuce planted subsequently made satisfactory growth on this land when copper was used whereas in earlier years they had failed completely. Runner beans grown without copper on similar soil showed small yellowish leaves with burnt edges, and flowers were sparse on stunted plants only 2 feet tall at the time of inspection. In the case of those treated with copper, the plants were 3 feet tall, the leaves were of normal size and of good colour and flowers were numerous.

Copper sulphate has been so beneficial on this property that Mr. Hortin is now using it generally on his cropped land.

b. Mr. J. Wolfe's property, Bornholm, 1938.

The results on Mr. Hortin's property led Mr. J. Wolfe to conduct some tests on his adjoining farm. An experiment on a virgin wet heath soil of the Plantagenet peaty sand type (described by Hosking and Burvill (1938)), and known locally as bottle brush country, showed that an excellent stand of subterranean clover, cocksfoot, prairie grass, and other pasture species was obtained if dressed with copper sulphate at the rate of 15 lbs. per acre. The surface heath and fibrous surface soil was merely broken to a depth of about 4 inches with a heavy plough, burnt as soon as dry, and sown down in the autumn with the pasture mixture and copper sulphate without superphosphate. Improved growth resulted on an area where superphosphate and ammonia were applied in the following spring. Without copper sulphate a very inferior growth of *Lotus major* and Yorkshire fog resulted as other species failed to grow past the seedling stage.

This type of land covers extensive areas along the south coast. Sir John Russell, on the occasion of his inspection of the area on 26th January, 1939, stated that this soil type, the Plantagenet peaty sand, resembled those of Holland on which reclamation disease occurs and where copper sulphate has proved beneficial for crops and stock.

Early efforts to establish pastures on this type of country met with indifferent success with the usual fertiliser mixtures. Baron Hay (1933) describes the methods adopted for development and records the failure of the pasture even where a "complete" fertiliser is used. Yorkshire fog was the most promising species tried. The discovery of the effect of copper sulphate now promises to improve the prospect for pasture establishment on this soil type. Even Yorkshire fog, which is very tolerant of copper deficiency, requires top dressing with copper sulphate on this soil type on Mr. Wolfe's property to maintain a sound rooting system and firm crown.

On some sandy loam soils of karri hills on the same property, some 7 acres of pasture were dressed with copper sulphate at the rate of 8 lbs. per acre in 1938. The pasture was a good sward of perennial rye grass, paspalum and subterranean clover. It appeared to benefit from the copper sulphate and Mr. Wolfe believes that the stock, brought in from the coastal sandhills, improved in condition more rapidly than usual and showed some preference for the treated pasture.

Tomatoes apparently respond to copper sulphate on the Plantagenet peaty sand types. Planted with the usual potato manure tomatoes failed to grow and developed a bunchy habit with yellow foliage. When watered with dilute copper sulphate solution excellent growth and fruiting resulted.

Mr. J. Wilkinson of the same district has made similar observations. He found that about 2 ounces of copper sulphate per gallon of water was the maximum usable without injury to the plants.

Mr. Wilkinson has also observed that Wimmera rye grass will grow normally on certain of these poor sandy soils if dressed with copper sulphate.

c. Observations on Saidie Swamp, Young's Siding, 1938-39.

The sandy swamp karri soils of Saidie swamp have been found to yield a satisfactory first crop of potatoes, but "deteriorate" rapidly with subsequent cropping. This "deterioration" may be avoided by the use of seed grown in Benger Swamp or on strong soil types of other districts (see Fig. 1.) and preliminary results indicate that the use of copper sulphate at the rate of 15 lbs. per acre will

accomplish a similar result. During the 1938-39 season Mr. Kurt Martin has obtained excellent growth of potatoes on "deteriorated" land as a result of using copper sulphate with the usual fertilisers. Seed from plots which had received copper seemed to give a better response than those from areas not treated with copper, probably owing to an improved tuber resulting from the treatment. Manganese and zinc, in addition to the copper, may be beneficial.

Fig. 5.

Growth of local and Benger seed with and without "minor" elements on Mr. E. Cake's farm, Young's Siding. Right pair: local seed without "minor" elements. Middle pair: local seed with 16 lbs. per acre each of copper sulphate and manganese sulphate. Left pair: Benger seed with similar treatment to middle pair. Photo.: L. J. H. Teakle.

Fig. 5 shows the top growth from local seed, local seed plus copper and manganese, and Benger seed. The Benger seed has produced the most vigorous top growth but no yield comparisons will be available on account of destruction by the floods of 13th January.

Cabbages on similar soil on Mr. E. Cake's adjoining property produced marketable heads only where copper was used. Without copper growth was poor and the lower leaves were pale yellow in colour and of a papery consistency. Mr. J. Wolfe has observed similar responses with copper.

d. Observation on Mr. J. T. Rutherford's holding, Torbay, February, 1939.

From the observation of Mr. G. K. Baron Hay (private communication) it seems that maize will grow on the Plantagenet peaty sand type where small dressings of copper are used. Mr. Rutherford ploughed an area of this wet, semi-bottlebrush country and allowed it to lie fallow over the winter of 1938. In spring it was worked down and sown to maize with superphosphate and superphosphate plus ammonia. By way of an experiment, four rows received copper sulphate at the rate of 6 lbs. per acre with superphosphate. At the end of February, 1939, where the copper was used, the maize was 4 to 6 feet tall, uniformly vigorous and a good green colour. Elsewhere, except at the sites of fires, the plants generally had

grown to a height of only one foot and were yellow in colour and dying or dead. It is interesting that on the sites of fires the growth of the maize equalled that of the copper treated rows.

5. Experiments on Mr. F. Wittenoom's property, Maida Vale.

On account of unsatisfactory yields of potatoes on an acidic peaty sand on Mr. F. Wittenoom's property, Maida Vale (10 miles east of Perth), a randomised block experiment with potatoes was arranged. The land was planted on 8th and 9th August and harvested on 28th November, 1938. The growth throughout the period was never vigorous and there were no obvious responses to treatment. Irish blight caused some loss and soil conditions proved harmful in certain small patches.

The results of the experiment are given in Table 3.

Table 3.

Yield of potatoes on Mr. F. Wittenoom's farm, Maida Vale. All "minor" element salts applied at the rate of 20 lbs. per acre. Control mixture consisted of sulphate of ammonia (4 cwts. per acre), superphosphate (12 cwts. per acre), sulphate of potash (2 cwts. per acre).

Treatment.	Yield per acre.		Per cent. of Control.
	tons.	cwts.	
Control	10	5	100
Control plus zinc sulphate	9	12	94
„ „ borax	9	9	92
„ „ manganese sulphate	9	8	92
„ „ copper sulphate	9	14	95
„ „ copper sulphate, manganese sulphate, zinc sulphate, magnesium sulphate, borax	9	3	89

As the mean square for error exceeded that for treatment, there is no significant difference between any of the treatments and it must be concluded that the "minor" elements did not affect the growth or yield of potatoes on this land.

The marked response of potatoes in "minor" elements on a number of soil types in the Albany district along the south coast and the absence of response along the west coast (where, incidentally response to potash is obtained) are probably correlated with differences in the composition of the rocks of the two localities. Mr. F. G. Forman, the Government Geologist, has observed that the rocks of the Darling Range are much richer in minerals than those along the south coast and it is reasonable to conclude that the mineral composition of the associated soils would reflect similar differences.

It is interesting, too, that with the exception of one instance on Mr. J. Wolfe's property, no responses have been observed to the treatment of *established* pastures with copper, manganese and zinc in a number of cases in the Albany district, on the Denmark Research Station, at Manjimup and in the Busselton areas. Of course, it seems likely that *established* pastures have become adapted to the environment and will not ordinarily respond to treatment with "minor" elements. Responses may be detected only when attempts are made to develop more desirable species which require a more generous supply of certain factors. However, such spectacular responses as have been reported cannot be expected to be very general except in certain localities and on certain soil types.

In those areas apparently copper deficient, general observations indicate that plants apparently tolerant of copper deficiency include Yorkshire fog (*Holcus lanatus*), drooping flowered clover (*Trifolium cernuum*), Lotus major, rye (*Secale cereale*) and millet. Plants which appear to be most responsive to copper applications on deficient soils are wheat, oats, barley, turnips, swedes, cabbages, lettuce, peas, beans, tomatoes, onions, cocksfoot (*Dactylis glomerata*), prairie grass (*Bromus unioloides*), and wimmera rye grass (*Lolium rigidum* var *subulatum*).

6. *Conclusions.*

From the results of experiments reported above it may be concluded that—

(a) On marly peat soils of coastal swamps in the Albany district manganese sulphate is likely to benefit a variety of crops, including potatoes, runner beans, cabbages, swedes, turnips, peas and tomatoes. Copper, in addition to manganese, may be beneficial with peas, swedes and cabbages.

(b) On a number of acidic soil types, including swamp soils, soils of bottle brush flats and brown sandy soils of karri hills of the Albany district, copper has proved of considerable benefit to truck crops, potatoes, and pastures.

(c) On the agricultural soils of the western coastal plain south of Perth no evidence of response of potatoes, truck crops or pastures to "minor" elements has been obtained. A geological basis for this difference is suggested.

(d) It does not seem necessary to use copper sulphate or manganese sulphate at a rate in excess of 15 lbs. per acre and lower rates may be adequate.

(e) The residual effect of "minor" elements in the soil is observed in the growth of the crop grown in the following year.

To be continued.

AGRICULTURAL PROBLEMS.

Agriculturists, pastoralists and primary producers generally, who may be having difficulties of any kind in connection with their production activities, are invited to communicate with the Agricultural Adviser of their district of the Department of Agriculture, when information and advice will be supplied free of charge.

Where identification of plant or stock diseases or insect pests is required, full details of symptoms should be forwarded and also samples of the diseased plant, animal tissue or insect where practicable. Plant tissue intended for examination by the Plant Pathologist should be wrapped in paper and not forwarded in airtight containers, and plant specimens for the Botanist should be pressed between newspaper and dried before despatch. With regard to animal tissue for microscopic examination, this should be forwarded in a solution of 10 per cent. formalin, or if of considerable bulk in a sealed kerosene tin containing a few ounces of formalin as a preservative. Living insects should be sent in suitable containers and dead specimens in methylated spirits.

The addresses and names of Advisers are as follows:—

Albany	H. R. Powell (Fruit); B. Williams (Dairying).
Bridgetown	A. Flintoff (Fruit); A. M. Tindale (Dairying).
Bunbury	M. Cullity.
Geraldton	N. Davenport (Government Buildings).
Gosnells	R. C. Owen.
Harvey	R. L. Cailes (Fruit).
Katanning	A. S. Wild.
Kalamunda-Roleystone	W. H. Read, c/o. Department of Agriculture, Perth.
Kununoppin	W. M. Nunn.
Manjimup	C. M. Scott.
Metropolitan, Gingin, Chittering ...	S. E. Bennett, c/o. Department of Agriculture, Perth.
Mundaring	V. Cahill.
Narrogin	A. T. Gulvin.
Vasse	J. M. Nelson.

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